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A Laboratory Evaluation of Certain Features of Cotton Housework Dress Construction

Bureau of Human Nutrition and Home Economics
Agriculture Research Administration

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CONTENTS

- Materials — 3
- Strength of seams — 6
  - Experimental procedure — 7
    - Preparation and breaking of test specimens — 8
    - Statistical measures — 10
  - Results — 11
    - Effect of variants on breaking strength of seams — 11
    - Breaking-strength findings compared with those of previous studies — 35
    - Effect of variants on elongation of seams at point of break — 36
    - Relation of variants to damage to thread or fabric as a result of the break — 37
- Strength at patch pocket corners — 40
  - Methods of attaching patch pockets in ready-made housework dresses — 41
  - Experimental procedure — 42
    - Making test pockets — 42
    - Balancing tensions on stitching threads — 44
    - Measuring tension — 45

Strength at patch pocket corners—Continued

Experimental procedure—Con.

- Evaluating methods of attaching patch pockets — 46
- Results — 46
  - Effect of variants on breaking strength at pocket corners — 46
  - Effect of variants on elongation at pocket corners — 51
  - Relation of variants to type of damage at rupture of pocket corners — 54
- Abrasion resistance of buttonholes — 55
  - Experimental procedure — 57
    - Preparation of test specimens — 57
    - Abrading the buttonholes — 57
  - Results — 60
- Summary — 65
  - Strength of seams — 65
  - Strength at patch pocket corners — 66
  - Abrasion resistance of buttonholes — 68
- Literature cited — 68

TABLES

1. Physical properties of fabrics — 2
2. Significance of differences between means of physical properties of fabrics — 3
3. Physical properties of warp and filling yarns of high-, medium-, and low-count cotton prints — 4
4. Significance of differences between means of physical properties of fabrics and yarns in warp and filling directions — 4
5. Significance of differences between means of physical properties of fabrics and yarns in different qualities of prints — 4
6. Physical properties of sewing threads — 5
7. Significance of differences between means of physical properties of sewing threads — 5
8. Analysis of variance for breaking strength of seams; medium-count fabrics — 11
9. Mean breaking strength, in pounds, of plain, lapped, and stitched fell seams; medium-count fabric — 12
10. Mean breaking strength, in pounds, of plain, standing fell, and French seams; medium-count fabrics — 13
11. Significance of differences between mean breaking strengths of warpwise, fillingwise, armscye, and shoulder seams—plain, lapped, and stitched fell; medium-count fabric — 14
12. Significance of differences between mean breaking strengths of warpwise, fillingwise, armscye, and shoulder seams—plain, standing fell, and French; medium-count fabrics — 15
13. Significance of differences between mean breaking strengths of plain, lapped, and stitched fell seams in six locations; medium-count fabric — 18
14. Significance of differences between mean breaking strengths of plain, standing fell, and French seams in six locations; medium-count fabrics — 19

Page
15. Analysis of variance for breaking strength of plain fillingwise and warpwise seams; high-, medium-, and low-count fabrics 30
16. Analysis of variance for breaking strength of plain, lapped, and stitched fell fillingwise seams; high-, medium-, and low-count fabrics 30
17. Analysis of variance for breaking strength of plain, French, and standing fell fillingwise seams; high-, medium-, and low-count fabrics 31
18. Analysis of variance for breaking strength of plain fillingwise seams with three sizes of stitches; high-, medium-, and low-count fabrics 31
19. Analysis of variance for breaking strength of plain fillingwise seams with three kinds of thread; high-, medium-, and low-count fabrics 31
20. Analysis of variance for elongation of seams; medium-count fabrics 37
21. Approximate number of stitches in patterns of stitching at pocket corners 44
22. Analysis of variance for breaking strength at patch pocket corners; three patterns of stitching, three numbers of stitches per inch, four kinds of threads, three counts of fabric 50
23. Significance of differences between mean breaking strengths at corners of muslin patch pockets with seven patterns of stitching 50
24. Significance of differences between mean breaking strengths at corners of patch pockets, diagonally stitched, with and without reinforcements, and at corners of modified patch pockets 52
25. Analysis of variance of elongation at point of break at patch pocket corners made with three patterns of stitching, three numbers of stitches per inch, four kinds of thread, and three counts of fabric 52
26. Difference between means of elongation at point of break at corners of muslin patch pockets 53
27. Significance of differences between means of elongation at point of break at corners of patch pockets stitched diagonally, with and without reinforcements, and at corners of modified patch pockets 54
28. Abrasion resistance of whip (a) buttonholes worked fillingwise on high- and medium-count fabrics, with 3-cord mercerized A thread and various numbers of stitches per inch, and of so-called purl buttonholes worked similarly on medium-count fabric 59
29. Abrasion resistance of attachment-made buttonholes worked fillingwise on high- and medium-count fabrics with mercerized and unmercerized thread and various numbers of stitches per inch 59
30. Loss in breaking strength caused by abrading four sewing threads used in making buttonholes 62
31. Durability and energy coefficients of sewing threads calculated from abrasion and load-elongation curves 63

FIGURES

Page
1. Types of seams: Plain; lapped; French; standing fell; stitched fell 7
2. Directions of seam edges in relation to warp yarns in sections of test specimens indicated by angles of deviation 9
3. Effect of direction of seam on breaking strength of seams on medium-count fabric 20
4. Effect of direction of seam on breaking strength of seams on medium-count fabrics 21
5. Effect of kind of seam on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabric 22
6. Effect of kind of seam on breaking strength of skirt, hip, and armscye seams on medium-count fabric 23
7. Effect of kind of seam on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabrics 24
8. Effect of kind of seam on breaking strength of skirt, hip, and armscye seams on medium-count fabrics 25

Page
9. Effect of kind of thread on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabric — 26
10. Effect of kind of thread on breaking strength of skirt, hip, and armscye seams on medium-count fabric — 27
11. Effect of kind of thread on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabrics — 28
12. Effect of kind of thread on breaking strength of skirt, hip, and armscye seams on medium-count fabrics — 29
13. Breaking strength of plain fillingwise and warpwise seams on high-, medium-, and low-count fabrics with 3-cord mercerized 50 thread, 11 stitches per inch — 32
14. Comparison of strength of plain seams made fillingwise on high-, medium-, and low-count fabrics with warp strengths of the respective fabrics, and of seams made warpwise with the filling strengths of the respective fabrics — 32
15. Relationship of strength of plain seams made warpwise on high-, medium-, and low-count fabrics with filling counts of the respective fabrics; and of seams made fillingwise with the warp counts of the respective fabrics — 33
16. Comparison of breaking strength of plain, lapped, stitched fell, standing fell, and French seams made fillingwise, with 11 stitches per inch and 3-cord mercerized 50 thread, on high-, medium-, and low-count fabrics with the warp strength of the respective fabrics — 33
17. Relationship of strength of plain, lapped, stitched fell, standing fell, and French seams made fillingwise on high-, medium-, and low-count fabrics to the warp count of the respective fabrics — 34
18. Comparison of breaking strength of plain fillingwise seams made with 8, 11, and 14 stitches per inch on high-, medium-, and low-count fabrics, 3-cord mercerized 50 thread — 34
19. Comparison of breaking strength of plain fillingwise seams made with 6-cord unmercerized 50, 3-cord mercerized 50, and 2-cord mercerized 00 thread on high-, medium-, and low-count fabrics, with 11 stitches per inch — 35
20. Broken seams made with 14 stitches per inch on high- and low-quality fabrics: Plain; stitched fell; standing fell; French; lapped — 39
21. Ways of attaching patch and modified patch pockets — 41
22. Patch pocket specimens: Diagram of pocket, showing upper and lower jaws of strength tester; test specimen in process of being broken — 43
23. Tensometer and motor-driven winding device used for measuring the tension force: On the upper thread at a convenient stage in threading; on the lower thread — 45
24. Effect of pattern of stitching on breaking strength at corners of pockets made from fabrics with different counts — 48
25. Effect of quality of fabric on breaking strength at corners of patch pockets made from fabrics with different counts — 49
26. Effect on breaking strength at pocket corners of pattern of stitching on muslin pockets, of reinforcing diagonally stitched corners with tape, and of modifying patch pocket construction by inserting sides in lapped seams with single and with double stitching — 51
27. Buttonholes: Whipstitch, attachment-made; whipstitch, machine-made; so-called purl stitch, machine-made — 56
28. Machine used in abrading buttonholes and detail of abrading area — 58
29. Relationship of abrasion cycles and number of stitches per inch for whip and so-called purl buttonholes worked fillingwise with 3-cord mercerized A thread on fabrics with different counts — 60
30. Effect of kind of thread and number of stitches per inch on abrasion resistance of whip buttonholes worked fillingwise with a buttonhole attachment on fabrics with different counts — 61
31. Comparison of abrasion-rate curves of sewing threads — 62
32. Load-elongation curves of mechanically conditioned sewing threads — 64

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UNITED STATES DEPARTMENT OF AGRICULTURE

A Laboratory Evaluation of Certain Features of Cotton Housework Dress Construction

By Mary C. Whitlock, *formerly of the Bureau of Human Nutrition and Home Economics*, Florence E. Petzel, *formerly of The Ohio State University*, and Bess V. Morrison and Hazel M. Fletcher, *Bureau of Human Nutrition and Home Economics, Agricultural Research Administration*[1]

Seams, patch pockets, and buttonholes are details of housework dresses that frequently fail to contribute to the serviceability of the garments. To obtain basic information on the effect of fabric, number of stitches per inch, and thread on the breaking strength and elongation of stitching and patch pocket corners and on the abrasion resistance of buttonholes, the Bureau of Human Nutrition and Home Economics, in cooperation with The Ohio State University and the Ohio Agricultural Experiment Station, conducted research on the relative durability of these details of garment construction. In addition, the direction and kind of seams used, the pattern of the pocket corner stitching, and the type of stitch in the buttonhole were studied. For seams and pocket specimens, damage to thread, stitching, or fabric was noted.

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[1] The studies of strength of seams and pocket corners were conducted at The Ohio State University under the immediate supervision of Florence E. Petzel, in cooperation with Mary C. Whitlock; the buttonhole study was conducted at the Bureau of Human Nutrition and Home Economics by Hazel M. Fletcher and Mary C. Whitlock. Bess V. Morrison, Head of the Textiles and Clothing Division of the Bureau, served as consultant and coordinator.

Appreciation is expressed to the following members of The Ohio State University staff: Eve E. Turnbull who directed the laboratory work for 3 months, Henri J. Hoffman and Paul Bucher who aided in developing measuring devices, and Robert Gardner who aided in the analysis of data; to the Singer Sewing Machine Company for making some of the buttonholes for the study; to Earl C McCracken of the Bureau staff who assisted with the development of a buttonhole abrading machine; and to Bureau research assistants who conducted repetitive tests.

TABLE 1.—*Physical properties of fabrics*

Fabric	Weight[1] per square yard (conditioned)	Thickness [1]	Count [1]		Breaking strength [2]				Elongation [2]			
			Warp	Filling	Warp		Filling		Warp		Filling	
					Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Seam study:												
Prints:	*Ounces*	*Inches*	*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
High A	3.5	0.010	85	77	52.35	1.36	37.25	4.79	12.67	1.41	26.67	1.57
Medium B	2.6	.009	69	59	41.65	1.49	25.70	1.74	8.33	1.76	17.67	1.61
Medium C	2.7	.010	69	56	41.30	3.00	[3] 24.00	.87	10.00	0	22.22	1.92
Medium D	2.6	.010	70	56	42.55	1.79	22.15	1.36	10.00	0	21.00	1.61
Low E	2.4	.009	62	45	43.45	2.11	17.85	2.21	6.67	0	15.67	1.61
Pocket study:												
Prints:												
High F	4.7	.012	76	68	56.10	3.63	46.70	3.22	12.23	1.61	23.67	1.89
Medium G	3.8	.009	63	52	44.02	3.72	32.91	1.87	6.25	2.20	16.25	1.32
Medium H	2.9	.010	74	62	40.70	4.63	23.75	1.89	9.00	1.61	20.67	2.11
Low I	2.3	.008	64	55	33.20	1.99	21.20	2.21	7.67	1.61	12.67	1.41
Muslin J	3.6	.010	92	78	50.90	1.44	37.35	3.85	12.50	[4] 0	25.00	1.76
Buttonhole study:												
Prints:												
High K	2.6		80	80	41.55	2.81	28.60	1.98	5.30	.91	12.60	1.64
Medium L	2.7		73	61	40.85	1.72	23.35	1.63	4.93	.38	13.13	.94
Medium M	2.7		68	53	33.35	3.03	16.30	2.54	3.83	.42	8.97	2.03
Medium N	2.4		70	55	37.73	1.53	17.79	1.37	6.70	.44	9.00	.68
Low O	2.2		60	45	31.68	1.54	13.35	.65	4.30	.39	6.70	.69

[1] Mean of 10 determinations.

[2] Mean and standard deviation of 10 determinations. Grab test for seam study; strip test for pocket and buttonhole studies.

[3] Mean of 3 determinations.

[4] Standard deviation less than 0.005.

MATERIALS

Cotton fabrics—high-, medium-, and low-quality prints—commonly used in housework dresses were selected for the research. When the project was initiated in 1944, it was difficult to obtain sufficient yardage identical in physical properties for each of the three qualities desired for the study. Consequently several small lots of fabric had to be used. For example, it was necessary to use three pieces of medium-count print, instead of one, for the study on strength of seams.

Fabrics used in the study are identified in table 1. The physical properties of the materials, as determined by standard methods (*1*),[2] and the significance of some of the differences among groups of fabrics are given in tables 1 to 5.

Both unmercerized threads (classified by the trade as soft finish) and mercerized threads used for home sewing or commercial production of housework dresses were included in the study. The kinds and sizes were: Unmercerized, 6-cord 50, 6-cord 60, and 3-cord 50; mercerized, 3-cord 50, 3-cord A, 2-cord 00, and 2-cord in an unnumbered size. The physical properties of the threads and the significance of some of the differences among the groups are given in tables 6 and 7.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 68.

TABLE 2.—*Significance of differences between means of physical properties of fabrics, as indicated by* t *values*

Fabrics compared	Count		Breaking strength [1]		Elongation [2]	
	Warp	Filling	Warp	Filling	Warp	Filling
Seam study[3]**:**						
A vs. B	**53.125	**50.519	**16.790	**7.175	**6.091	**12.650
A vs. C	**49.331	**50.360	**10.610	**4.633	**6.000	**4.114
A vs. E	**54.828	**87.743	**11.208	**11.636	**13.499	**15.461
B vs. C	.318	**7.364	.330	1.602	**3.000	**4.140
B vs. E	**17.294	**45.881	*2.200	**8.830	**3.000	*2.778
C vs. E	**17.049	**30.712	1.852	**4.592	(4)	**5.957
Pocket study:						
F vs. H	.895	**12.259	**8.278	**19.417	**4.629	**3.349
F vs. I	**34.124	**25.462	**17.478	**20.615	**6.481	**14.758
H vs. I	**4.287	**16.202	**4.710	*2.771	1.852	**9.984

*Significant at 5-percent level.

**Significant at 1-percent level.

[1] Values of *t* based on grab-breaking strengths for fabrics used in seam study; on strip-breaking strengths for fabrics used for pocket study.

[2] Values of *t* for elongation calculated on basis of measurements in inches.

[3] Fabric D not included in the calculations.

[4] Value could not be calculated because the variance was 0. This difference may be presumed to be significant at the 1-percent level.

TABLE 3.—*Physical properties of warp and filling yarns of high-, medium-, and low-count cotton prints*

Fabric [1]	Yarn number		Twists per inch		Breaking strength		Elongation	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
	Grex	*Grex*	*Number*	*Number*	*Grams*	*Grams*	*Percent*	*Percent*
A	179	135	19	22	181	117	4.7	4.9
B	175	139	20	23	188	136	3.5	4.7
C	179	125	19	24	210	104	5.0	5.0
E	217	14	17	20	238	101	4.4	5.4

[1] These particular properties were not determined for fabric D.

TABLE 4.—*Significance of differences between means of physical properties of fabrics and yarns in warp and filling directions, as indicated by* t *values*

Fabric [1]	Properties of fabrics			Properties of yarns			
	Yarns per inch	Breaking strength	Elongation [2]	Yarn [3] number	Twist	Breaking strength	Elongation [4]
A	**20.099	**9.600	**21.000	**11.884	**5.048	**11.240	1.195
B	**34.333	**22. 42	**12.384	**18.668	**9.573	**8.838	**9.900
C	**34.602	**9.59	**22.627				
E	**40.793	**26.459	**17.673	**23.099	**4.543	**25.655	**7.466

**Significant at 1-percent level.

[1] Fabric D not included in the calculations.

[2] Values of *t* calculated on basis of measurements in inches.

[3] Values of *t* calculated on basis of weight in grams of 10 yards of yarn.

[4] Values of *t* calculated on basis of measurements in centimeters.

TABLE 5.—*Significance of differences between means of physical properties of fabrics and yarns in different qualities of prints, as indicated by* t *values*

Fabrics [1] compared	Yarn number [2]		Twist		Breaking strength		Elongation [3]	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
A vs. B	*3.098	1.030	0.990	**2.849	0.980	**4.155	**8.150	**9.972
A vs. E	**21.028	1.507	**4.182	**3.387	**8.668	**2.894	*2.016	**3.158
B vs. E	**19.167	0.963	**4.480	**8.126	**7.352	**7.834	**7.299	**5.035

*Significant at 5-percent level.

**Significant at 1-percent level.

[1] Fabrics C and D omitted from these calculations.

[2] Values of *t* calculated on basis of weight in grams of 10 yards of yarn.

[3] Values of *t* calculated on basis of measurements in centimeters.

TABLE 6.—*Physical properties of sewing threads*

Threads	Marked size	Yards per pound [1]	Turns per inch [2]		Breaking strength[3]	Elongation [4]
			Ply	Single		
Seam study:						
Unmercerized:		*Yards*	*Number*	*Number*	*Pounds*	*Percent*
6-cord	50	13,357	23.8	34.9	2.33	6.6
Mercerized:						
3-cord	50	14,805	15.3	20.1	2.39	3.5
2-cord	00	14,546	18.6	17.6	1.78	4.0
Pocket study:						
Unmercerized:						
6-cord	50	13,542	23.7	34.8	2.28	6.5
3-cord	50	13,295	19.5	20.4	2.30	2.9
Mercerized:						
3-cord	50	14,073	14.5	19.1	2.29	3.7
2-cord	00	14,675	18.3	18.5	1.83	4.1
Buttonhole study:						
Unmercerized:						
6-cord	50	13,608	24.7	36.2	2.25	6.1
6-cord	60	15,204	25.5	38.9	2.11	6.1
Mercerized:						
3-cord	A	16,708	16.9	25.4	2.22	3.9
2-cord	--------	17,192	17.3	24.4	1.63	4.2

[1] Mean of weights of four 60-yard skeins. [2] Mean of 30 determinations.
[3] Mean of 40 determinations using a single-strand method.
[4] Mean of 40 determinations measured to the nearest 0.01 inch.

TABLE 7.—*Significance of differences between means of physical properties of sewing threads, as indicated by* t *values*

Threads compared	Yards per pound	Twists per inch		Breaking strength	Elongation [1]
		Ply	Single		
Seam study:					
6-cord unmercerized vs.—					
3-cord mercerized	**9.396	**42.601	**21.561	1.253	**23.319
2-cord mercerized	**11.928	**21.221	**26.015	**16.244	**25.451
3-cord mercerized vs.—					
2-cord mercerized	2.059	**15.465	**8.373	**13.693	**4.174
Pocket study:					
6-cord unmercerized vs.—					
3-cord unmercerized	1.293	**22.596	**15.592	.591	**26.715
3-cord mercerized	*3.110	**52.898	**16.837	.208	**19.706
2-cord mercerized	**6.216	**22.562	**17.995	**15.193	**17.473
3-cord unmercerized vs.—					
3-cord mercerized	**4.667	**26.942	**3.163	.210	**6.915
2-cord mercerized	**7.731	**4.691	**5.390	**16.269	**11.937
3-cord mercerized vs.—					
2-cord mercerized	**3.839	**16.131	1.550	**11.886	**3.949

*Significant at 5-percent level. **Significant at 1-percent level.
[1] Values of *t* calculated on the basis of measurements in inches.

STRENGTH OF SEAMS

The strength of seams in utility garments is influenced by many factors, including quality of fabric and thread, size of stitch and number of stitchings, kind and width of seams, and direction of the seams in relation to the warp and filling yarns of the fabric. The purpose of this study was to determine the effect of selected factors on the breaking strength at right angles to the seam, or, in other words, across the seam, and upon elongation at point of break. At the same time, an opportunity was provided to analyze the interactions of the factors in breaking strength as well as to examine the results of the break upon the fabric and threads in the seams.

According to Federal Specification DDD–S–751, a seam should be of sufficient strength to withstand the strain to which it will be subjected in the use or wear of the article of which it is a part (*18*). The specification lists the following factors as affecting seam strength: Type of stitch; combination of threads; number of stitches per unit length of seam; and tightness and construction of the seam. The specification further states that a seam should be durable, look well, and have a certain degree of elasticity.

Keeney, Watson, and Thompson observed in a serviceability study of chambray blouses that 10 stitches per inch were satisfactory for plain armscye seams when two rows of stitching were used (*11*). They also found that for top-stitched seams, 12 to 15 stitches per inch gave a more durable finish than a smaller number of stitches. Williams stated that a low number of stitches might contribute to slippage at seams (*22*).

Whitsel recognized the importance of the number of stitches per inch, number of rows of stitching, and of breaking strength of thread for determining seam strength (*21*). Williams estimated that when the strain on a seam is borne by two parallel rows of stitching, the strength is twice as high as with a single line of stitching (*23*).

Regarding the amount of seam strength, Edgerton stated that "the average woman exerts 20 pounds of strength or pull on tight seams. Therefore, fabrics intended for serviceable dresses should withstand at least 20 pounds of tensile strength" (*7*). Williams estimated the force exerted on garments to be 40 pounds, and on occasion, 50 pounds (*23*).

Williams found that the kind of seam had a direct bearing on breaking strength (*23*). Results of his study showed that seams made from a soft, fine English cotton fabric (limbric), with 15 stitches per inch and with a minimum allowance or turned-under portion of one-half inch, ranked in breaking strength as follows: Hem and fell (hemmed fell); machine fell (stitched or flat fell); overlaid; single (plain); French; flannel; and mantle makers (similar to standing fell).

Lewis reported that when measuring test seams of different widths the strength did not increase when specimen width was increased beyond 1½ inches (*13*). Williams found that the strength of plain seams on cotton limbric with seam allowances wider than one-half inch were not significantly stronger than those with one-half inch allowance (*23*).

The literature revealed no standard test for measuring strength of seams. Petzel, in a previous study, used a modified grab test when measuring seams stitched with different kinds of sewing threads (*15*).

EXPERIMENTAL PROCEDURE

Before the present study was made, commercial practices in seam construction were examined on 91 dresses in 10 stores in Columbus, Ohio, to learn what kinds of seams, seam finishes, and threads are commonly used in ready-made housework dresses. The information was a basis for planning the experimental work.

In the laboratory study the following variants were tested: Kind of seam; direction of fabric yarns in relation to the seams; size of stitch; kind of thread; and count of the fabric.

Breaking strengths were determined for plain, lapped, French, standing fell, and stitched fell seams (fig. 1). These seams were

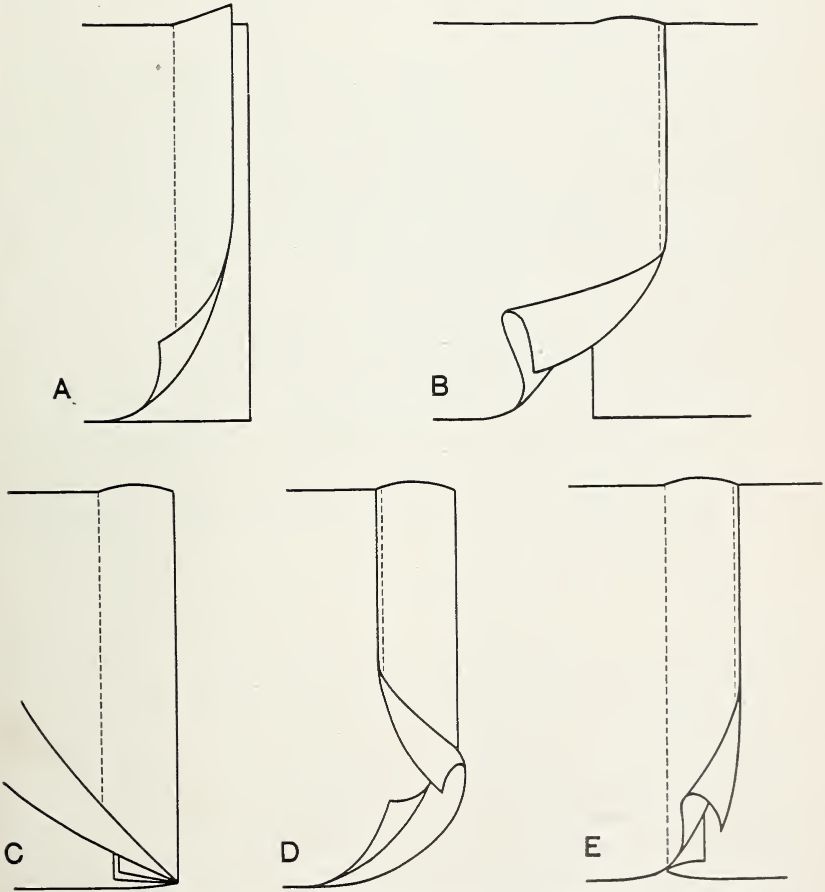

FIGURE 1.—Types of seams: *A*, Plain; *B*, lapped; *C*, French; *D*, standing fell; *E*, stitched fell.

made in the following directions on the fabric: Warpwise; fillingwise; and with the seams at such angles to the warp yarns as would be found in a side skirt seam at and below the curved hip area, at the lower back armscye, and in the shoulder of a princess-type dress (fig. 2). These locations include those at which seams are subject to strain in garments and often fail. For brevity, seams in these directions are hereafter referred to as warpwise, fillingwise, hip, skirt, armscye, and shoulder seams.

In the first phase of the study, medium-count prints that were as similar as could be procured were used (fabrics B, C, and D). The variables were seam-fabric (a combination of kind of seam and the fabric), direction of yarns in seam, size of stitch, and thread. Plain seams were made on fabrics B, C, and D; lapped and stitched fell seams on fabric B; and French and standing fell seams on fabrics C and D. All the seams were made in all six directions (warpwise, fillingwise, hip, skirt, armscye, and shoulder). Three lengths of stitch (8, 11, and 14 stitches per inch) and three threads (unmercerized 6-cord 50, and mercerized 3-cord 50 and 2-cord 00—table 6) were used.

When the data for the first phase of the study indicated marked seam-fabric differences in warpwise and fillingwise seams, and small but fairly consistent differences when fabrics with only slightly varying characteristics were used, another phase was undertaken to determine the influence of fabrics of different counts on breaking strength and elongation of seams of the same kinds. High-count print A, medium-counts B and C, and low-count E were used for the following kinds of seams, with the constants and variables as indicated:

1. Plain seams, warpwise and fillingwise, with mercerized 3-cord 50-thread; 11 stitches per inch.
2. Plain fillingwise seams with mercerized 3-cord 50-thread; 8, 11, and 14 stitches per inch.
3. Plain fillingwise seams with unmercerized 6-cord 50-thread and mercerized 3-cord 50 and 2-cord 00-threads; 11 stitches per inch.
4. Plain, lapped, French, standing fell, and stitched fell seams made fillingwise with mercerized 3-cord 50-thread; 11 stitches per inch.

PREPARATION AND BREAKING OF TEST SPECIMENS

The yardage for each phase of the study was divided into 10 blocks. From each block, one seam specimen was cut for each variant to be studied, and one specimen for each physical property to be tested, thus providing 10 specimens, the average of which, with the exceptions noted, is reported in table 1.

Specimens for warpwise and fillingwise seams were cut with the warp yarns in the positions shown in figure 2, *A* and *B*. The specimens for the other seams were identical with portions of seams in a princess dress pattern intended for a person with the average bust and hip measurements as reported by O'Brien and Shelton in a study of women's measurements (*14, p. 95*). Each section for the skirt and hip seams was cut with the seam line at a small angle

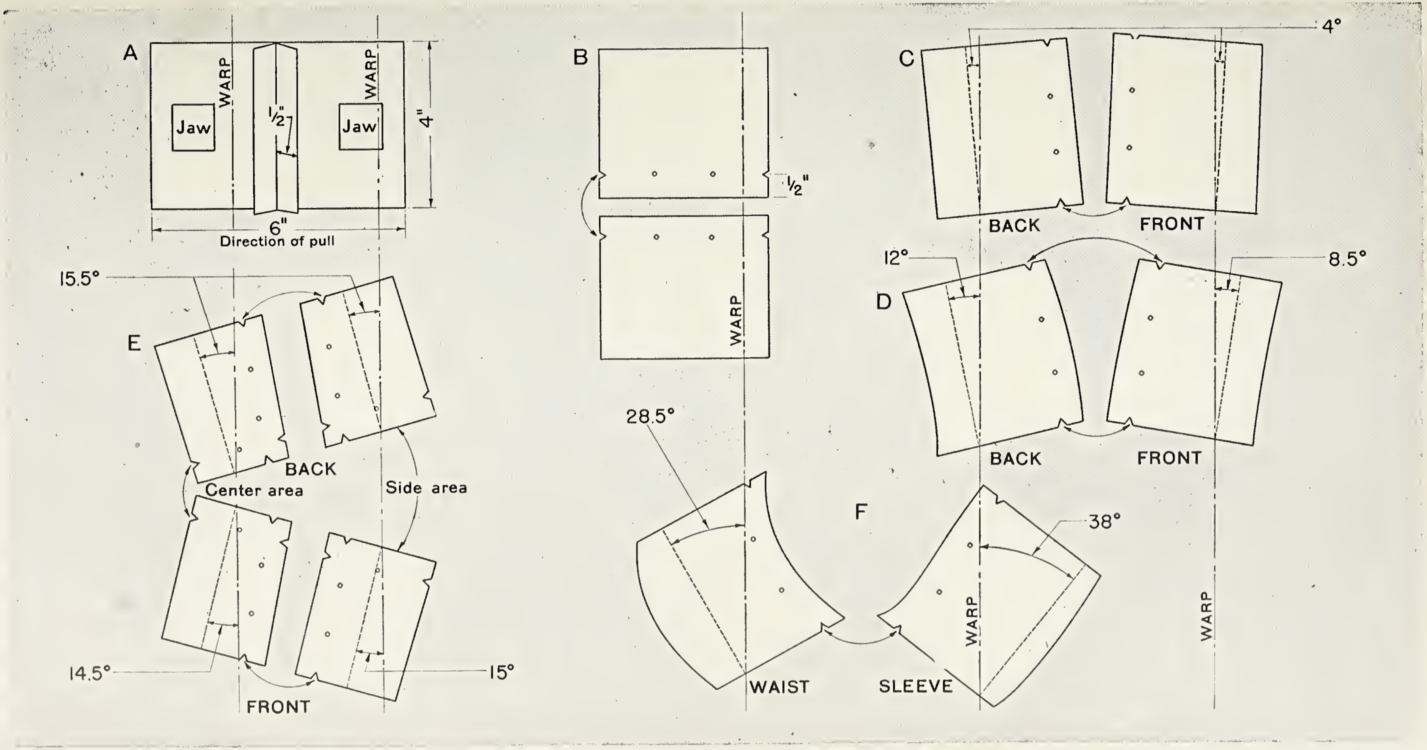

FIGURE 2.—Directions of seam edges in relation to warp yarns in sections of test specimens indicated by angles of deviation. Seams: *A*, warpwise; *B*, fillingwise; *C*, skirt; *D*, hip; *E*, shoulder; *F*, armscye. *A* also shows finished size of specimen, location for jaws of strength tester, and direction of pull when specimen is tested.

from the warp yarns (fig. 2, *C* and *D*). The shoulder seam formed an angle with the filling yarns of the fabric. The angle for each section of the shoulder seam, as shown in figure 2, *E*, is between a line at right angles to the edge of the shoulder seam and the warp line. In the sleeve and waist parts of the armscye seams, the seam lines curved along lines at indicated angles from the warp yarns (fig. 2, *F*). One-half inch was allowed on all specimens for seams.

In figure 2, *A*, the finished size of the specimens is indicated, as well as the location for the upper and lower front jaws in the breaking-strength machine, and the direction of pull on the specimen.

Specimens were basted and then stitched on a lock-stitch, family-type sewing machine having an oscillating shuttle. A needle of the size recommended for number 50 thread was used. Adjustments for length of stitch were acceptable when an average of five readings 1 inch apart was within a ± tolerance of one-half stitch of the desired number of stitches.

Tensions were balanced for the stitching each time a change was made in the number of thicknesses of fabric in the seam, in the quality of fabric, kind of thread, or length of stitch. The criteria for a balanced tension were: (1) Stitching looked alike on both sides; (2) upper and lower threads broke simultaneously (bias stitching test described by Holbrook and Krewatch, *10*); and (3) percentage of crimp in upper and lower threads was nearly equalized[3].

When a balanced tension was achieved, the tension force on the bobbin thread was recorded at a convenient stage in the threading process, by means of a tensometer with the thread pulled by a motor-driven winding device. The method described on page 45 was used, except that the bobbin case was held in a clamp attached to a ring stand instead of by hand.

The breaking strengths of seams were determined on a pendulum-type constant-rate-of-load fabric strength tester. Thread strengths were determined on an incline-plane machine, using the single-strand method. All tests of fabric, thread, and seams were performed under standard test conditions (*1*).

Percent elongation was measured from the charts on which the breaking strength of the seams was recorded. The damage resulting from the breaking process was classified according to thread breaks, fabric breaks at or away from the seam, and yarn slippage at the seam.

STATISTICAL MEASURES

An analysis of variance was made to determine the relative importance of the variables in the breaking strength and elongation of seams. Significance of differences between means of breaking strength and between means of elongation was determined by the t test.

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[3] Bias stitching test and determination of crimp are described more fully on page 44.

RESULTS

EFFECT OF VARIANTS ON BREAKING STRENGTH OF SEAMS

Because the seams were at right angles to the direction of pull, the filling yarns bore the strain when warpwise seams were broken; and, conversely, warp yarns bore the strain when fillingwise seams were broken. With shoulder, armscye, hip, and skirt seams, both sets of yarns bore the strain during the breaking of the seams, but one set was usually subjected to more strain than the other. In the hip and skirt seams, the force was exerted more directly on the filling yarns than on the warp. In the shoulder seams, the force was exerted largely on the warp yarns, although the angle at which the yarns met the strain was different for the front and back sections of the seam. In the armscye seams, the strain was more equally distributed on both warp and filling yarns than in the other seams.

For the seams made from the medium-count prints in the first part of the study, the effect of each of the four variables on the breaking strength of the seam was highly significant (table 8). Of these variables, the direction of the yarns of the fabric in relation to the seams had the greatest influence on breaking strength. The other variants, in descending order of importance, were seam-fabric, length of stitch, and kind of thread.

DIRECTION OF FABRIC YARNS IN RELATION TO SEAMS.—As shown in tables 9 and 10, the breaking strengths for armscye and filling-

TABLE 8.—*Analysis of variance for breaking strength of seams; medium-count fabrics B, C, and D*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Kind of seam-fabric (S)	5	29,818.61	5,963.72	**757.15
Direction of seam (D)	5	88,171.41	17,634.28	**2,238.83
Kind of thread (T)	2	616.73	308.36	**39.15
Length of stitch (L)	2	1,380.94	690.47	**87.66
S x D	25	14,872.05	594.88	**75.53
S x T	10	324.22	32.42	**4.12
S x L	10	1,072.95	107.30	**13.62
D x T	10	521.64	52.16	**6.62
D x L	10	11,893.20	1,189.32	**150.99
T x L	4	130.76	32.69	**4.15
S x D x T	50	761.21	15.22	**1.93
S x D x L	50	294.74	5.89	.75
S x T x L	20	306.78	15.34	**1.95
D x T x L	20	529.33	26.47	**3.36
S x D x T x L	100	4,315.64	43.16	**5.48
Experimental error	2,916	22,968.10	7.88	----------
Total	3,239	177,978.31	----------	----------

**Significant at 1-percent level.

wise seams ranged between 19.5 and 41.0 pounds; for warpwise, skirt, and hip seams the strengths ranged between 11.6 and 27.9 pounds. Shoulder seams were sometimes in the stronger and sometimes in the weaker group (figs. 3 and 4).

All the armscye seams were significantly stronger than the warpwise seams, and approximately half of them were stronger than the fillingwise seams (tables 11 and 12). This greater strength of armscye seams (crosswise of the seam) may have resulted from the fact that warp and filling yarns each bore some of the strain.

TABLE 9.—*Mean breaking strength, in pounds, of plain, lapped, and stitched fell seams; medium-count fabric B*

Kind of seam and thread, number of stitches per inch	Location of seam					
	Fillingwise	Shoulder	Warpwise	Skirt	Hip	Armscye
Plain seam:						
6-cord unmercerized:						
8	27.4	15.8	24.0	22.5	22.2	33.3
11	31.2	19.4	22.9	20.4	20.8	38.0
14	30.0	24.2	21.3	19.3	20.3	36.6
3-cord mercerized:						
8	21.3	13.2	24.4	22.0	21.6	29.1
11	32.6	18.6	23.3	21.2	21.7	33.0
14	29.9	23.8	19.8	20.2	20.6	36.4
2-cord mercerized:						
8	24.1	12.8	23.7	21.7	22.6	30.2
11	28.8	16.2	24.1	22.2	21.8	31.5
14	30.8	21.2	21.3	19.6	19.7	33.8
Lap seam:						
6-cord unmercerized:						
8	28.5	15.9	24.3	20.8	21.8	33.5
11	32.6	20.5	23.2	21.1	19.8	35.9
14	29.4	21.8	21.4	19.7	20.3	36.3
3-cord mercerized:						
8	25.2	13.5	24.4	22.8	21.0	30.9
11	31.7	18.0	22.5	20.3	21.3	34.7
14	31.0	24.8	21.2	20.9	22.2	37.7
2-cord mercerized:						
8	22.8	12.2	21.8	21.1	18.9	29.2
11	28.5	18.0	23.4	20.5	20.4	32.3
14	27.8	20.0	20.7	19.3	20.6	32.2
Stitched fell seam:						
6-cord unmercerized:						
8	41.0	33.1	27.2	24.7	24.0	33.9
11	39.0	40.6	26.5	23.7	22.0	34.2
14	37.5	40.4	25.4	23.8	23.2	40.2
3-cord mercerized:						
8	40.7	31.5	27.8	23.8	22.0	36.8
11	40.1	33.2	26.6	22.2	22.2	32.1
14	37.4	40.1	25.3	23.0	22.4	35.0
2-cord mercerized:						
8	38.3	29.2	27.9	22.8	23.3	37.2
11	40.4	36.9	25.2	23.0	21.3	33.7
14	38.0	37.1	25.9	23.3	23.4	34.7

A large majority of the fillingwise seams were significantly stronger than the warpwise seams and nearly one-third of them were significantly stronger than armscye seams (tables 11 and 12). The superior strength of fillingwise over warpwise seams was probably related to the fact that the warp yarns of the fabrics were stronger than the filling yarns (table 1).

For the most part, fillingwise seams were significantly stronger than shoulder seams. In two cases where the highest strength for shoulder seams was attained (with the stitched fell method), however, the reverse was true (tables 11 and 12).

TABLE 10.—*Mean breaking strength, in pounds, of plain, standing fell, and French seams; medium-count fabrics C and D*

Kind of seam and thread, number of stitches per inch	Location of seam					
	Filling-wise	Shoulder	Warp-wise	Skirt	Hip	Armscye
Plain seam:						
6-cord unmercerized:						
8	27.4	17.1	20.6	19.2	21.7	31.0
11	32.2	20.5	19.9	18.1	21.3	33.2
14	35.2	23.6	17.8	16.9	19.7	32.5
3-cord mercerized:						
8	23.8	13.5	20.8	19.6	20.4	30.5
11	35.2	19.5	19.0	17.7	21.4	31.8
14	35.4	28.1	17.1	17.0	19.8	29.4
2-cord mercerized:						
8	21.2	13.5	19.8	19.7	21.8	30.2
11	32.1	18.2	19.6	18.3	20.8	29.6
14	34.0	26.1	17.4	17.5	18.8	31.9
Standing fell seam:						
6-cord unmercerized:						
8	27.2	19.8	17.5	17.0	18.6	29.2
11	30.4	18.7	15.3	14.7	17.4	24.7
14	25.8	27.0	12.8	11.2	15.0	30.4
3-cord mercerized:						
8	26.1	16.9	19.0	16.8	18.7	27.0
11	25.6	17.2	13.7	12.6	16.5	30.2
14	19.5	27.7	13.7	14.2	14.4	29.4
2-cord mercerized:						
8	25.1	14.0	18.4	15.9	18.7	28.9
11	29.5	20.7	12.4	15.0	17.0	29.4
14	25.6	24.1	14.3	11.6	11.8	29.9
French seam:						
6-cord unmercerized:						
8	28.2	16.0	21.1	19.3	21.3	31.0
11	35.8	20.3	18.7	17.5	20.1	31.6
14	35.1	28.5	17.1	17.2	19.4	34.2
3-cord mercerized:						
8	24.6	14.7	20.7	19.5	22.0	29.9
11	31.8	20.6	18.8	18.0	20.8	33.0
14	34.9	25.8	17.7	16.9	19.0	32.2
2-cord mercerized:						
8	25.1	12.8	22.0	20.4	21.4	28.2
11	32.6	21.5	18.5	17.7	20.0	33.9
14	35.0	24.6	16.9	16.9	19.5	34.5

TABLE 11.—*Significance of differences between mean breaking strengths of warpwise, fillingwise, armscye, and shoulder seams—plain, lapped, and stitched fell; medium-count fabric B*

Position of seam, kind of thread, and number of stitches per inch	Kind of seam		
	Plain	Lapped	Stitched fell
	Pounds	*Pounds*	*Pounds*
Warpwise vs. fillingwise: [1]			
6-cord mercerized:			
8	**+3.4	**+4.2	**+13.8
11	**+8.3	**+9.4	**+12.5
14	**+8.7	**+8.0	**+12.1
3-cord mercerized:			
8	*3.1	+.8	**+12.9
11	**+9.3	**+9.2	**+13.5
14	**+10.1	**+9.8	**+12.1
2-cord mercerized:			
8	+.4	+1.0	**+10.4
11	**+4.7	**+5.1	**+15.2
14	**+9.5	**+7.1	**+12.1
Armscye vs. warpwise: [2]			
6-cord mercerized:			
8	**+9.3	**+9.2	**+6.7
11	**+15.1	**+12.7	**+7.7
14	**+15.3	**+14.9	**+14.8
3-cord mercerized:			
8	**+4.7	**+6.5	**+9.0
11	**+9.7	**+12.2	**+5.5
14	**+16.6	**+16.5	**+9.7
2-cord mercerized:			
8	**+6.5	**+7.4	**+9.3
11	**+7.4	**+8.9	**+8.5
14	**+12.5	**+11.5	**+8.8
Fillingwise vs. armscye: [3]			
6-cord mercerized:			
8	**5.9	**5.0	**+7.1
11	**6.8	**3.3	**+4.8
14	**6.6	**6.9	*2.7
3-cord mercerized:			
8	**7.8	**5.7	**+3.9
11	.4	*3.0	**+8.0
14	**6.5	**6.7	+2.4
2-cord mercerized:			
8	**6.1	**6.4	+1.1
11	*2.7	**3.8	**+6.7
14	*3.0	**4.4	**+3.3
Fillingwise vs. shoulder: [4]			
6-cord mercerized:			
8	**+11.6	**+12.6	**+7.9
11	**+11.8	**+12.1	1.6
14	**+5.8	**+7.6	*2.9
3-cord mercerized:			
8	**+8.0	**+11.7	**+9.2
11	**+14.0	**+13.7	**+6.9
14	**+6.1	+6.2	*2.7

TABLE 11.—*Significance of differences between mean breaking strengths of warpwise, fillingwise, armscye, and shoulder seams —plain, lapped, and stitched fell; medium-count fabric B*—Con.

Position of seam, kind of thread, and number of stitches per inch	Kind of seam		
	Plain	Lapped	Stitched fell
	Pounds	*Pounds*	*Pounds*
2-cord mercerized:			
8	**+11.3	**+10.6	**+9.1
11	**+12.6	**+10.5	**+3.5
14	**+9.6	**+7.8	+.9

*A difference of 2.46 pounds is significant at the 5-percent level.
**A difference of 3.23 pounds is significant at the 1-percent level.

[1] Plus indicates fillingwise seam was stronger than warpwise.

[2] Plus indicates armscye seam was stronger than warpwise.

[3] Plus indicates fillingwise seam was stronger than armscye.

[4] Plus indicates fillingwise seam was stronger than shoulder.

TABLE 12.—*Significance of differences between mean breaking strengths of warpwise, fillingwise, armscye, and shoulder seams —plain, standing fell, French; medium-count fabrics C and D*

Position of seam, kind of thread, and number of stitches per inch	Kind of seam		
	Plain	Standing fell	French
	Pounds	*Pounds*	*Pounds*
Warpwise vs. fillingwise:[1]			
6-cord mercerized:			
8	**+6.8	**+9.7	**+7.1
11	**+12.3	**+15.1	**+17.1
14	**+17.4	**+13.0	**+18.0
3-cord mercerized:			
8	*+3.0	**+7.1	**+3.9
11	**+16.2	**+11.9	**+13.0
14	**+18.3	**+5.8	**+17.2
2-cord mercerized:			
8	+1.4	**+6.7	*+3.1
11	**+12.5	**+17.1	**+14.1
14	**+16.6	**+11.3	**+18.1
Armscye vs. warpwise:[2]			
6-cord mercerized:			
8	**+10.4	**+11.7	**+9.9
11	**+13.3	**+9.4	**+12.9
14	**+14.7	**+17.6	**+17.1
3-cord mercerized:			
8	**+9.7	**+8.0	**+9.2
11	**+12.8	**+16.5	**+14.2
14	**+12.3	**+15.7	**+14.5
2-cord mercerized:			
8	**+10.4	**+10.5	**+6.2
11	**+10.0	**+17.0	**+15.4
14	**+14.5	**+15.6	**+17.6

TABLE 12.—*Significance of differences between mean breaking strengths of warpwise, fillingwise, armscye, and shoulder seams —plain, standing fell, French; medium-count fabrics C and D* —Continued

Position of seam, kind of thread, and number of stitches per inch	Kind of seam		
	Plain	Standing fell	French
	Pounds	*Pounds*	*Pounds*
Fillingwise vs. armscye:[3]			
6-cord mercerized:			
8	**3.6	2.0	*2.8
11	1.0	**+5.7	**+4.2
14	*+2.7	**4.6	+.9
3-cord mercerized:			
8	**6.7	.9	**5.3
11	**+3.4	**4.6	1.2
14	**+6.0	**9.9	*+2.7
2-cord mercerized:			
8	**9.0	**3.8	*3.1
11	*+2.5	+.1	1.3
14	+2.1	**4.3	+.5
Fillingwise vs. shoulder:[4]			
6-cord mercerized:			
8	**+10.3	**+7.4	**+12.2
11	**+11.7	**+11.7	**+15.5
14	**+11.6	1.2	**+6.6
3-cord mercerized:			
8	**+10.3	**+9.2	**+9.9
11	**+15.7	**+8.4	**+11.2
14	**+7.3	**8.2	**+9.1
2-cord mercerized:			
8	**+7.7	**+11.1	**+12.3
11	**+13.9	**+8.8	**+11.1
14	**+7.9	+1.5	**+10.4

*A difference of 2.46 pounds is significant at 5-percent level.

**A difference of 3.23 pounds is significant at 1-percent level.

[1] Plus indicates fillingwise seam was stronger than warpwise.

[2] Plus indicates armscye seam was stronger than warpwise.

[3] Plus indicates fillingwise seam was stronger than armscye.

[4] Plus indicates fillingwise seam was stronger than shoulder.

KIND OF SEAM.—On the whole, stitched fell seams were the strongest of the kinds studied (figs. 5 to 8). The degree of superiority, however, was influenced by the direction of the seam, that is, the location of the warp and filling yarns in the seam. For example, the stitched fell seams were much stronger than the plain and lapped seams in fillingwise and shoulder positions; they were significantly stronger, even though less markedly so, than most of the plain and lapped seams in the warpwise position. On the other hand, only a little less than a half of the stitched fell seams were significantly stronger than the plain and lapped seams in the skirt, hip, and armscye positions (table 13).

French seams were significantly stronger than the standing fell seams in about 70 percent of the tests, as were plain seams in about 60 percent of the tests (table 14). With few exceptions, plain and French seams made from similar prints, C and D, were not significantly different in strength, nor were plain and lapped seams made from print B (tables 13 and 14). In other words, it appeared that, in general, stitched fell seams were the strongest and standing fell the weakest, with little difference among the other types. The lower breaking strength of standing fell seams was associated with the tendency of the narrow edge of the seam to pull from the stitching.

SIZE OF STITCH.—Apparently the size of stitch had more effect on seams where the warp yarns or both the warp and filling yarns bore the strain than on those where the filling yarns bore the strain. For example, in general, fillingwise, shoulder, and armscye seams had substantial changes in strength related to size of stitch. On the other hand, differences in seam strengths of warpwise, skirt, and hip seams had little relationship to size of stitch (figs. 3 and 4). Figures 5 to 8 show the effect of size of stitch on seams of different kinds and on seams made with different threads.

The distribution of breaking strengths of seams made with stitches of various sizes reveals the influence of the size of the stitch. In many cases, the higher breaking strengths were associated with the higher numbers of stitches per inch. For example, among the seams with 25 or more pounds breaking strength, 47 were stitched with 14 stitches per inch; 41 with 11 stitches per inch; and 36 with 8 stitches per inch. When the lower limit of strength was dropped to 20 pounds, the number of stitches per inch apparently made little difference, since in this group the number of seams stitched with 8, 11, and 14 stitches per inch was 78, 77, and 74, respectively.

KIND OF THREAD.—In only approximately 25 percent of the tests were significant differences in seam strength associated with the kind of thread used. In approximately two-thirds of the significant cases, seams stitched with 6-cord unmercerized 50 thread were stronger than those stitched with 3-cord 50 or 2-cord 00 mercerized threads. As was true of size of stitch, the effect of kind of thread upon seam strength was more evident for seams in fillingwise, shoulder, and armscye positions than in the others (figs. 9 to 12).

TABLE 13.—*Significance of differences between mean breaking strengths of plain, lapped, and stitched fell seams in six locations; medium-count fabric B*

Kind of seam and thread, number of stitches per inch	Seam location					
	Filling-wise	Shoulder	Warp-wise	Skirt	Hip	Armseye
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Plain vs. lapped:[1]						
6-cord mercerized:						
8	1.1	0.1	0.3	+1.7	+0.4	0.2
11	1.4	1.1	.3	.7	+1.0	+2.1
14	+.6	+2.4	.1	.4	0	+.3
3-cord mercerized:						
8	**3.9	.3	0	.8	+.6	1.8
11	+.9	+.6	+.8	+.9	+.4	1.7
14	1.1	1.0	1.4	.7	1.6	1.3
2-cord mercerized:						
8	+1.3	+.6	+1.9	+.6	**+3.7	+1.0
11	+.2	1.8	+.7	+1.7	+1.4	.8
14	*+3.0	+1.2	+.6	+.3	.9	+1.6
Plain vs. stitched fell:[2]						
6-cord mercerized:						
8	**+13.6	**+17.3	*+3.2	+2.2	+1.8	+.6
11	**+7.8	**+21.2	**+3.6	**+3.3	+1.2	**3.8
14	**+7.5	**+16.2	**+4.1	**+4.5	*+2.9	**+3.6
3-cord mercerized:						
8	**+19.4	**+18.3	**+3.4	+1.8	+.4	**+7.7
11	**+7.5	**+14.6	**+3.3	+1.0	+.5	.9
14	**+7.5	**+16.3	**+5.5	*+2.8	+1.8	1.4
2-cord mercerized:						
8	**+14.2	**+16.4	**+4.2	+1.1	+.7	**+7.0
11	**+11.6	**+20.7	+1.1	+.8	.5	+2.2
14	**7.2	**+15.9	**+4.6	**+3.7	**+3.7	+.9
Lapped vs. stitched fell.[3]						
6-cord mercerized:						
8	**+12.5	**+17.2	*+2.9	**+3.9	+2.2	+.4
11	**+6.4	**+20.1	**+3.3	*+2.6	+2.2	1.7
14	**+8.1	**+18.6	**+4.0	**+4.1	*+2.9	**+3.9
3-cord mercerized:						
8	**+15.5	**+18.0	**+3.4	+1.0	+1.0	**+5.9
11	**+8.4	**+15.2	**+4.1	+1.9	+.9	*2.6
14	**+6.4	**+15.3	**+4.1	+2.1	+.2	*2.7
2-cord mercerized:						
8	**+15.5	**+17.0	**+6.1	+1.7	**+4.4	**+8.0
11	**+11.9	**+18.9	+1.8	*+2.5	+.9	+1.4
14	**+10.2	**+17.1	**+5.2	**+4.0	*+2.8	*+2.5

*A difference of 2.46 pounds is significant at the 5-percent level.
**A difference of 3.23 pounds is significant at the 1-percent level.

[1] Plus indicates plain seam is stronger than lapped.

[2] Plus indicates stitched fell seam is stronger than plain.

[3] Plus indicates stitched fell seam is stronger than lapped.

TABLE 14.—*Significance of differences between mean breaking strengths of plain, standing fell, and French seams in six locations; medium-count fabrics C and D*

Kind of seam and thread, number of stitches per inch	Seam location					
	Filling-wise	Shoulder	Warp-wise	Skirt	Hip	Armscye
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Plain vs. standing fell: [1]						
6-cord mercerized:						
8	+0.2	*2.7	*+3.1	+2.2	*+3.1	+1.8
11	+1.8	+1.8	**+4.6	**+3.4	**+3.9	**+8.5
14	**+9.4	**3.4	**+5.0	**+5.7	**+4.7	+2.1
3-cord mercerized:						
8	2.3	**3.4	+1.8	*+2.8	+1.7	**+3.5
11	**+9.6	+2.3	**+5.3	**+5.1	**+4.9	+1.6
14	**+15.9	+.4	**+3.4	*+2.8	**+5.4	0
2-cord mercerized:						
8	**3.9	.5	+1.4	**+3.8	*+3.1	+1.3
11	*+2.6	*2.5	**+7.2	**+3.3	**+3.8	+.2
14	**+8.4	+2.0	*+3.1	**+5.9	**+4.0	+2.0
Plain vs. French: [2]						
6-cord mercerized:						
8	.8	+1.1	.5	.1	+.4	0
11	**3.6	+.2	+1.2	+.6	+1.2	+1.6
14	+.1	**4.9	+.7	.3	+.3	1.7
3-cord mercerized:						
8	.8	1.2	+.1	+.1	1.6	+.6
11	**+3.4	1.1	+.2	.3	+.6	1.2
14	+.5	+2.3	.6	+.1	+.8	*+2.8
2-cord mercerized:						
8	**3.9	+.7	2.2	.7	+.4	+2.0
11	.5	**3.3	+1.1	+.6	+.8	**4.3
14	1.0	+1.5	+.5	+.6	.7	*2.6
Standing fell vs. French: [3]						
6-cord mercerized:						
8	1.0	**+3.8	**3.6	2.3	*2.7	1.8
11	**5.4	1.6	**3.4	*2.8	*2.7	**6.9
14	**9.3	1.5	**4.3	**6.0	**4.4	**3.8
3-cord mercerized:						
8	+1.5	+2.2	1.7	*2.7	**3.3	*2.9
11	**6.2	**3.4	**5.1	**5.4	**4.3	*2.8
14	**15.4	+1.9	**4.0	*2.7	**4.6	*2.8
2-cord mercerized:						
8	0	+1.2	**3.6	**4.5	*2.7	+.7
11	*3.1	.8	**6.1	*2.7	*3.0	**4.5
14	**9.4	.5	*2.6	**5.3	**4.7	**4.6

*A difference of 2.46 pounds is significant at the 5-percent level.

**A difference of 3.23 pounds is significant at the 1-percent level.

[1] Plus indicates plain seam was stronger than standing fell.

[2] Plus indicates plain seam was stronger than French.

[3] Plus indicates standing fell seam was stronger than French.

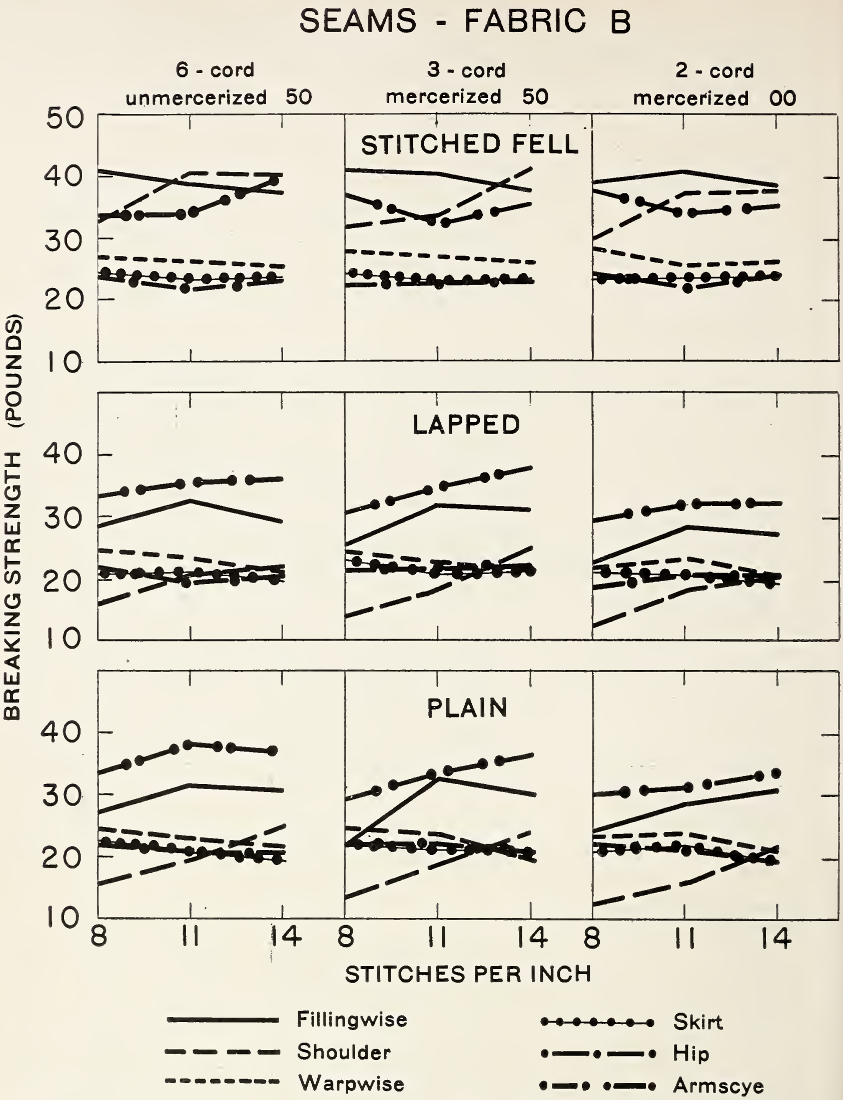

FIGURE 3.—Effect of direction of seam on breaking strength of seams on medium-count fabric.

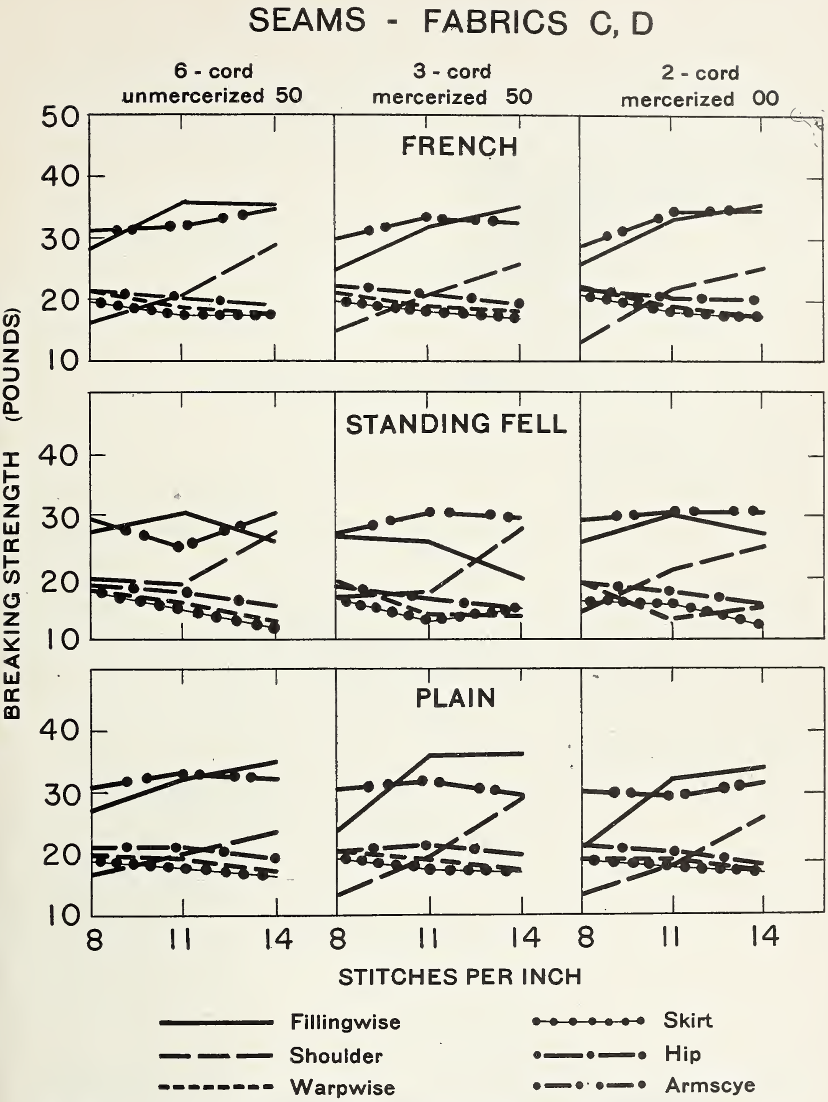

FIGURE 4.—Effect of direction of seam on breaking strength of seams on medium-count fabrics.

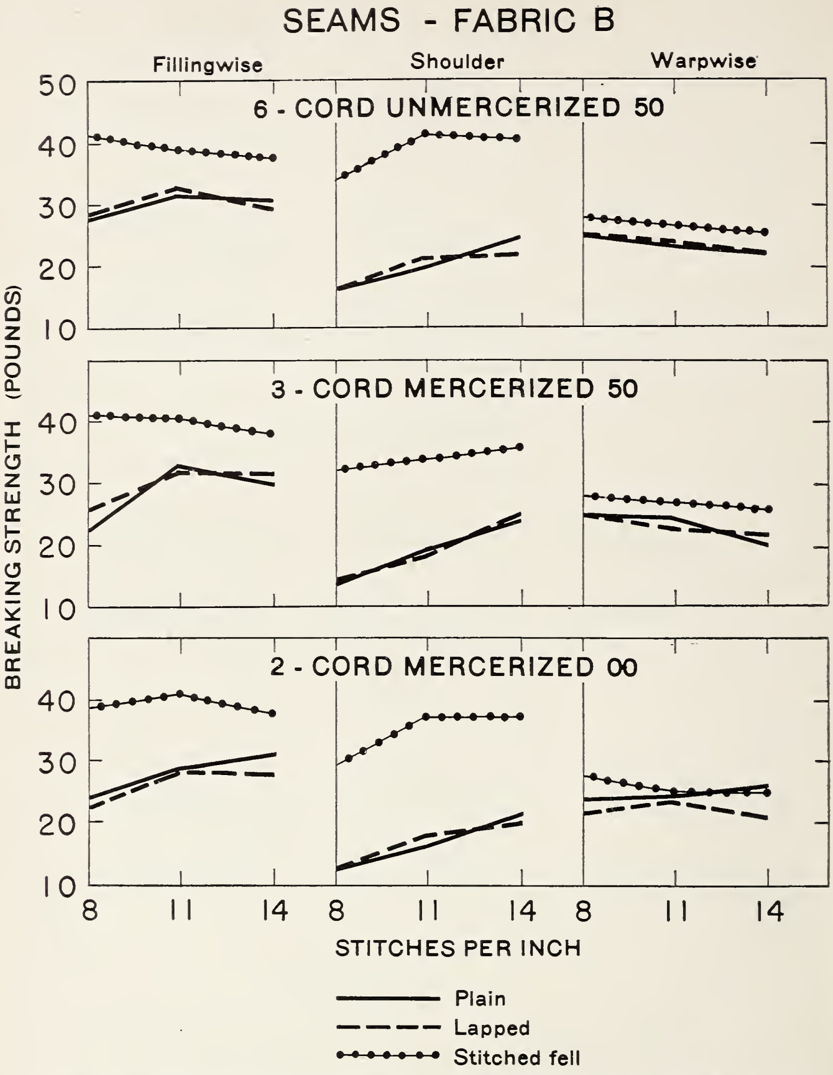

FIGURE 5.—Effect of kind of seam on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabric.

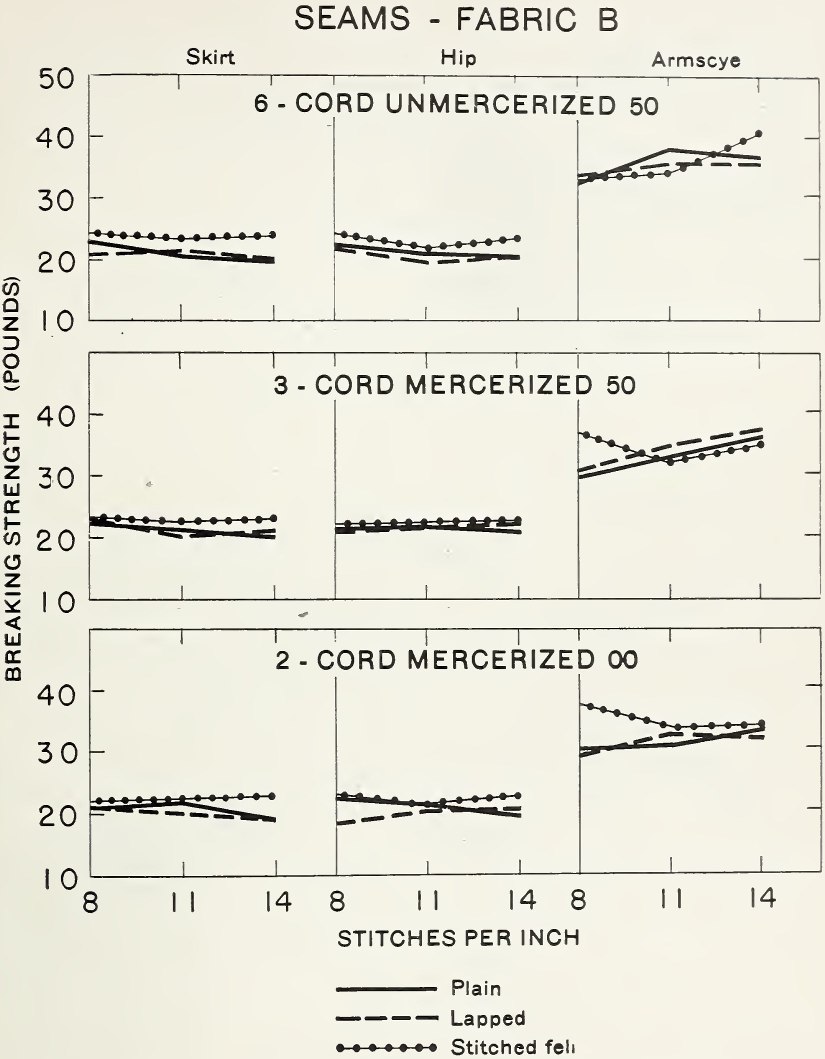

FIGURE 6.—Effect of kind of seam on breaking strength of skirt, hip, and armscye seams on medium-count fabric.

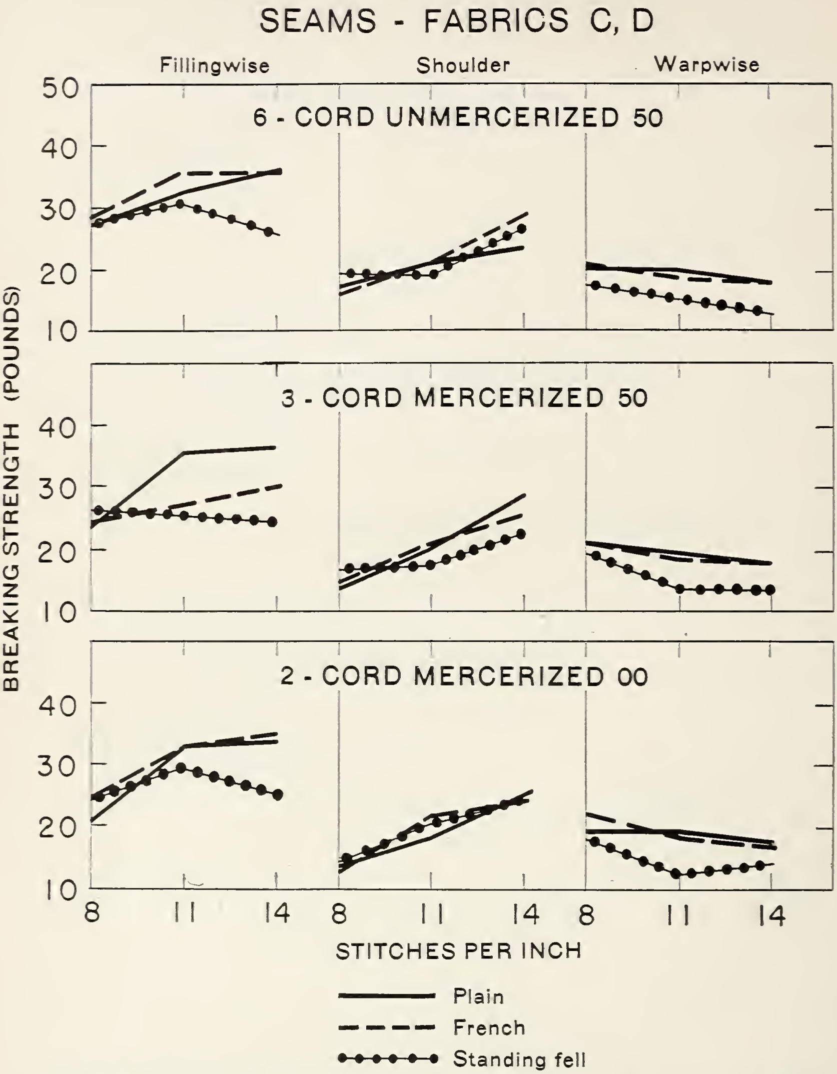

FIGURE 7.—Effect of kind of seam on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabrics.

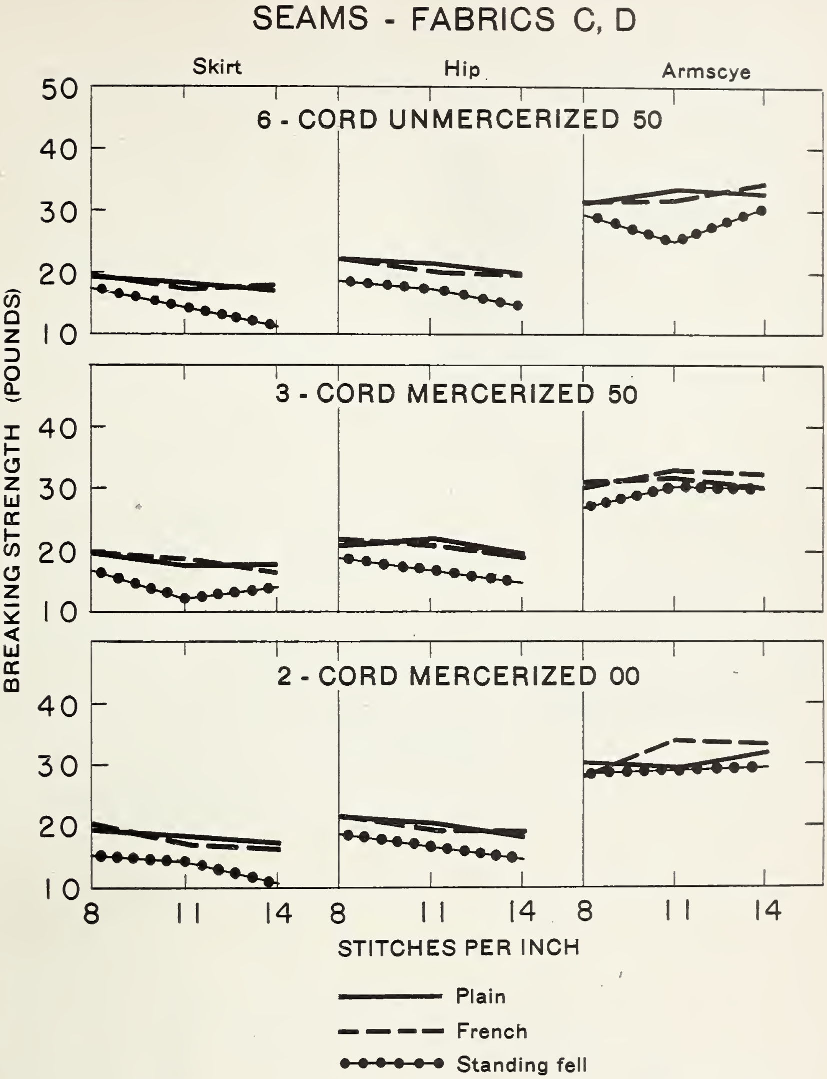

FIGURE 8.—Effect of kind of seam on breaking strength of skirt, hip, and armscye seams on medium-count fabrics.

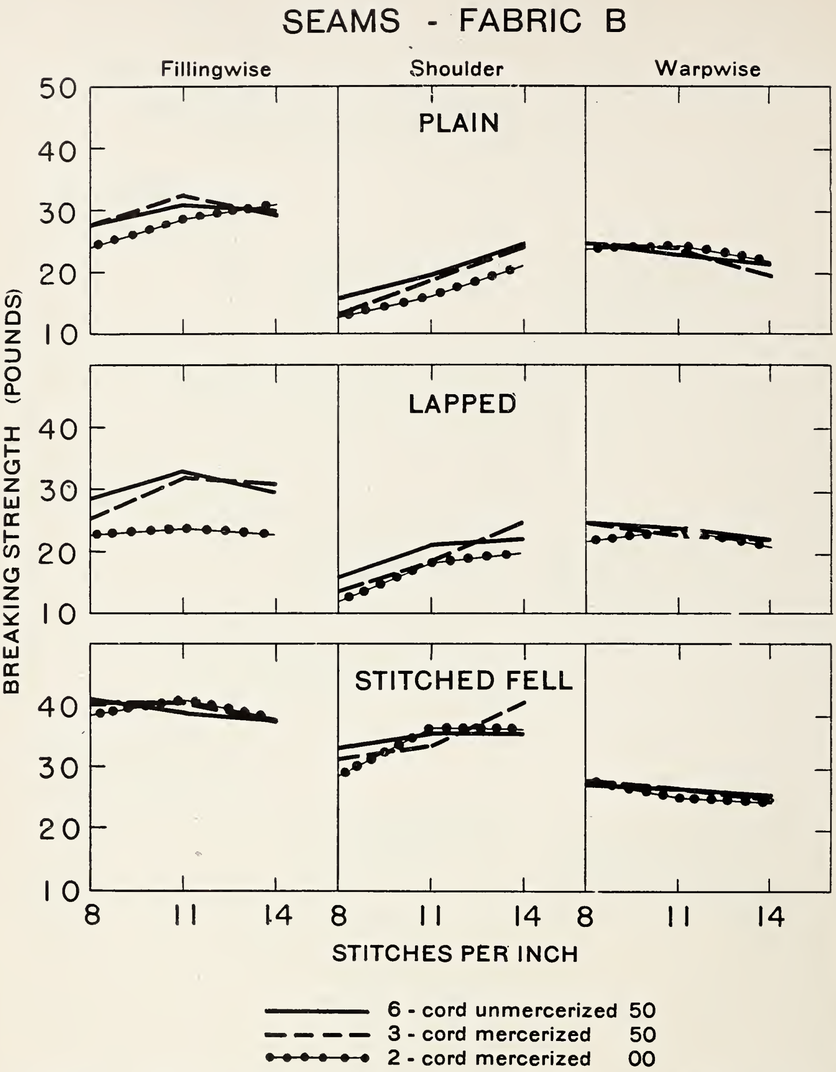

FIGURE 9.—Effect of kind of thread on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabric.

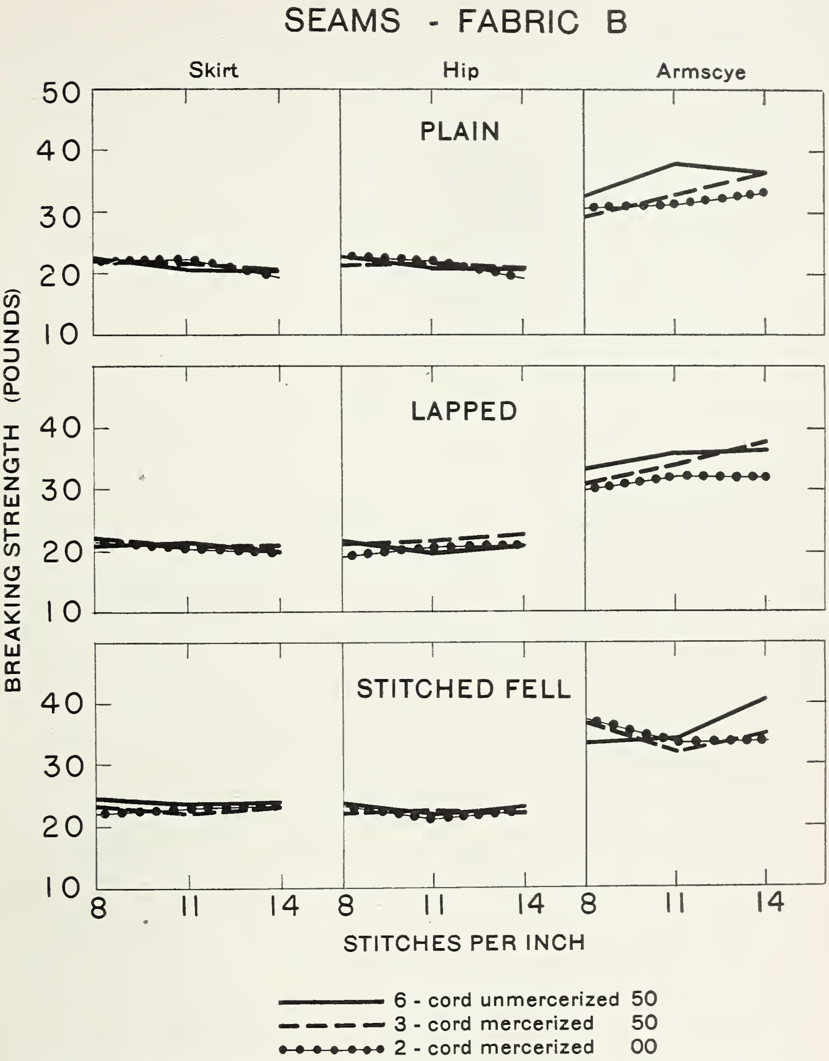

FIGURE 10.—Effect of kind of thread on breaking strength of skirt, hip, and armscye seams on medium-count fabric.

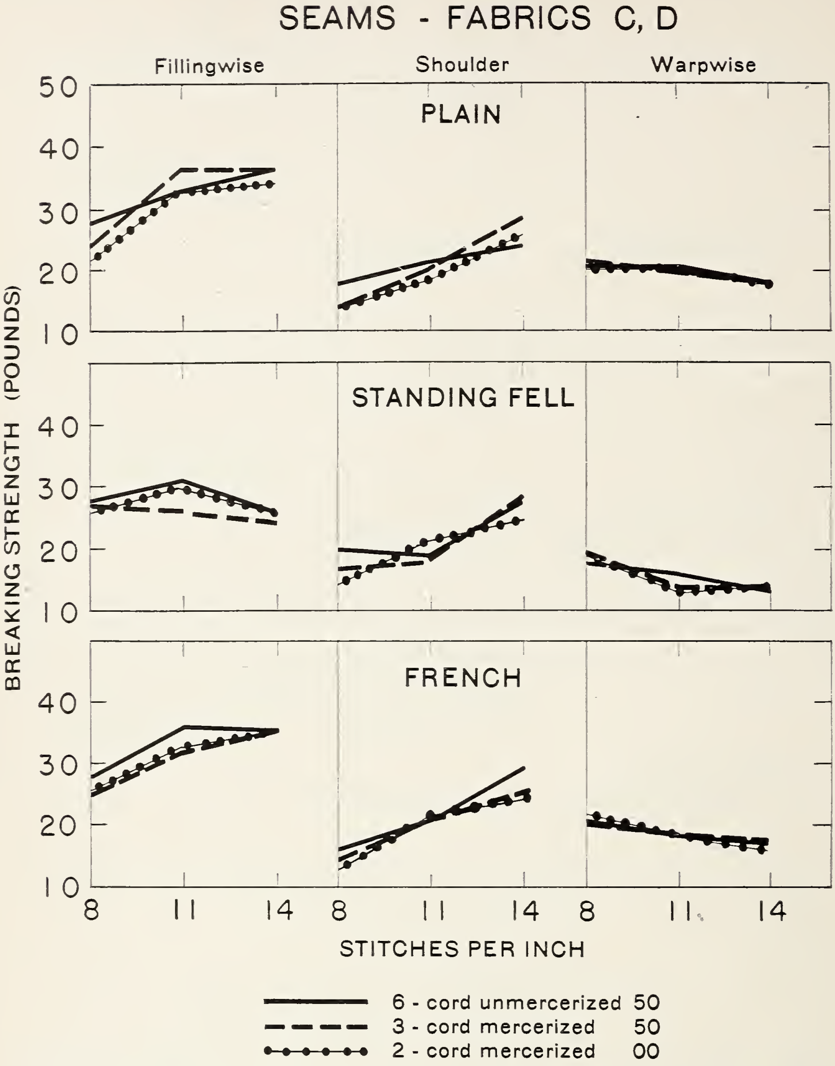

FIGURE 11.—Effect of kind of thread on breaking strength of fillingwise, shoulder, and warpwise seams on medium-count fabrics.

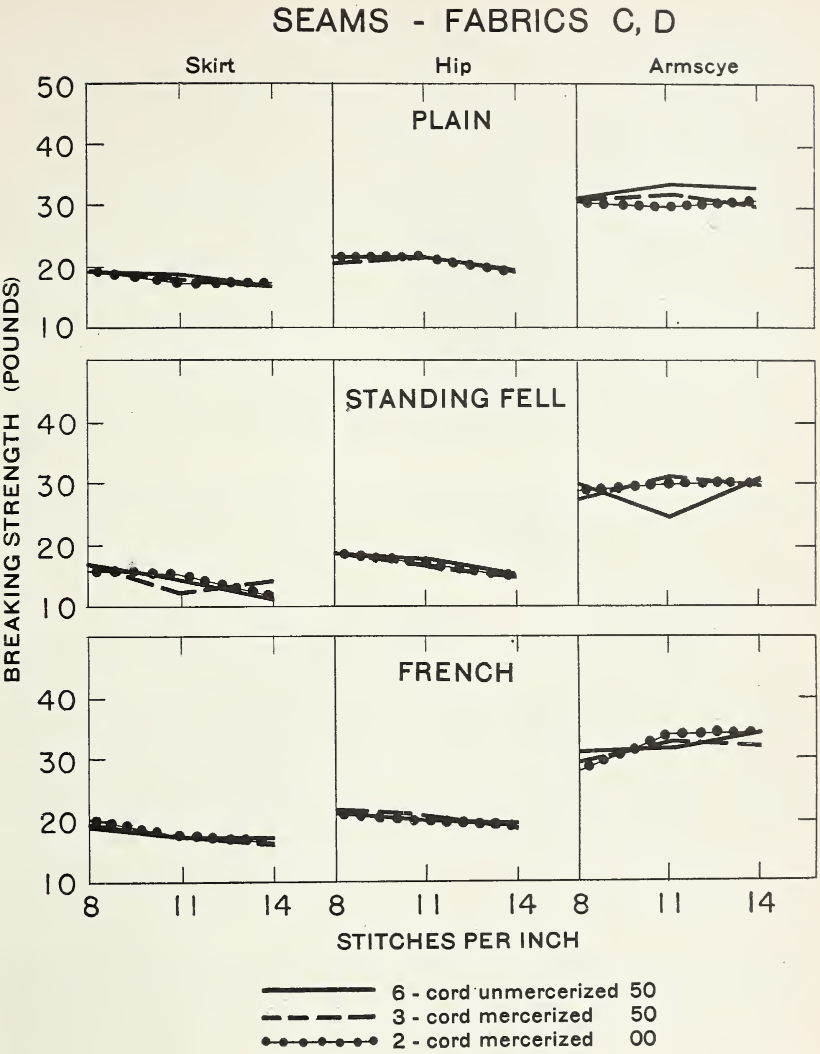

Figure 12.—Effect of kind of thread on breaking strength of skirt, hip, and armscye seams on medium-count fabrics.

FABRIC.—The kind of fabric used had a significant effect on the breaking strength of the following seams made from high-, medium-, and low-count prints: All five kinds of seams made fillingwise; plain seams made warpwise and fillingwise; and plain seams made with three sizes of stitches and three kinds of thread (tables 15 to 19).

Fillingwise plain seams were stronger than the warpwise seams when low- and medium-count prints were used, probably owing to the greater warp strength than filling strength of the fabrics (fig. 13, table 5). This effect of medium-count prints thus verified the findings in the first phase of the study. However, with high-count prints, plain seams in the two directions were approximately equal in strength, probably because of the more closely balanced weave of the high-count fabric.

Plain warpwise seams on each of the fabrics were just a little stronger than were the respective fabrics in the fillingwise direction, but the fillingwise seams were considerably weaker than were

TABLE 15.—*Analysis of variance for breaking strength of plain fillingwise and warpwise seams; high- (A), medium- (B and C), and low-count (E) fabrics*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	3	1,675.84	558.01	**107.63
Samples of same fabric	36	186.90	5.19	
Directions (D)	1	1,930.61	1,930.61	**230.11
F × D	3	725.74	241.91	**28.83
D × samples of same fabric	36	301.90	8.3	
Total	79	4,820.99		

**Significant at 1-percent level.

TABLE 16.—*Analysis of variance for breaking strength of plain, lapped, and stitched fell fillingwise seams; high- (A), medium- (B), and low-count (E) fabrics*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	2	250.24	125.12	**12.10
Samples of same fabric	27	279.17	10.34	
Seams (S)	2	1,250.07	625.04	**67.50
F × S	4	95.74	23.94	*2.58
S × samples of same fabric	54	500.35	9.26	
Total	89	2,375.58		

*Significant at 5-percent level.
**Significant at 1-percent level.

TABLE 17.—*Analysis of variance for breaking strength of plain, French, and standing fell fillingwise seams; high- (A), medium- (C), and low-count (E) fabrics*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	2	1,142.52	571.26	**33.68
Samples of same fabric	27	458.05	16.96	
Seams (S)	2	853.22	426.61	**25.87
F × S	4	351.59	87.90	**5.33
S × samples of same fabric	54	890.67	16.49	
Total	89	3,696.07		

**Significant at 1-percent level.

TABLE 18.—*Analysis of variance for breaking strength of plain fillingwise seams with three sizes of stitches; high- (A), medium- (B and C), and low-count (E) fabrics*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	3	546.96	182.32	**23.37
Samples of same fabric	36	280.96	7.80	
Length of stitches (L)	2	2,907.80	1,453.90	**203.63
F × L	6	473.07	78.84	**11.04
L × sample of same fabric	72	514.04	7.14	
Total	119	4,722.82		

**Significant at 1-percent level.

TABLE 19.—*Analysis of variance for breaking strength of plain fillingwise seams with three kinds of thread; high- (A), medium- (B and C), and low-count (E) fabrics*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	3	141.43	47.14	**4.47
Samples of same fabric	36	379.37	10.54	
Thread (T)	2	200.70	100.35	**11.74
F × T	6	292.71	48.78	**5.70
T × samples of same fabric	72	615.41	8.55	
Total	119	1,629.62		

**Significant at 1-percent level.

the fabrics in the warpwise direction (fig. 14). There was a progressive increase in breaking strength of plain warpwise seams made in fabrics with filling strengths ranging from low to high

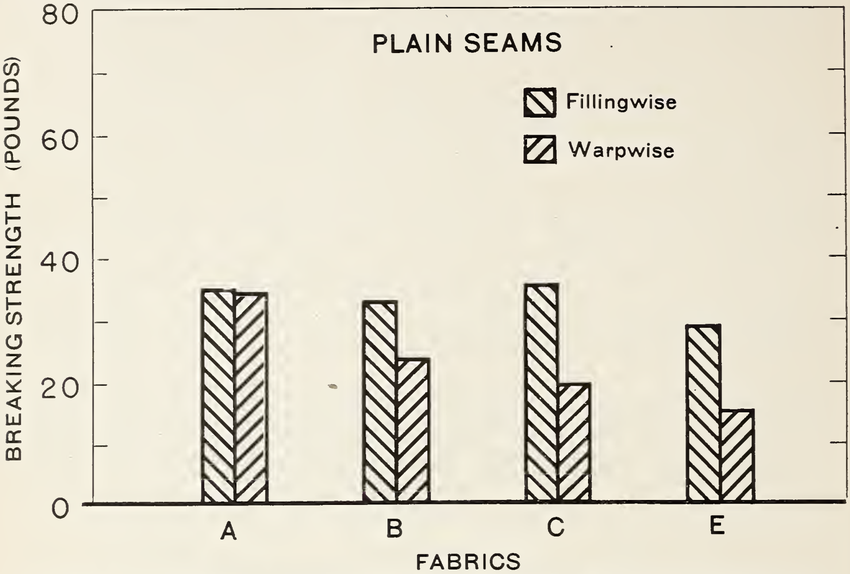

FIGURE 13.—Breaking strength of plain fillingwise and warpwise seams on high- (A), medium- (B and C), and low-count (E) fabrics with 3-cord mercerized 50 thread, 11 stitches per inch.

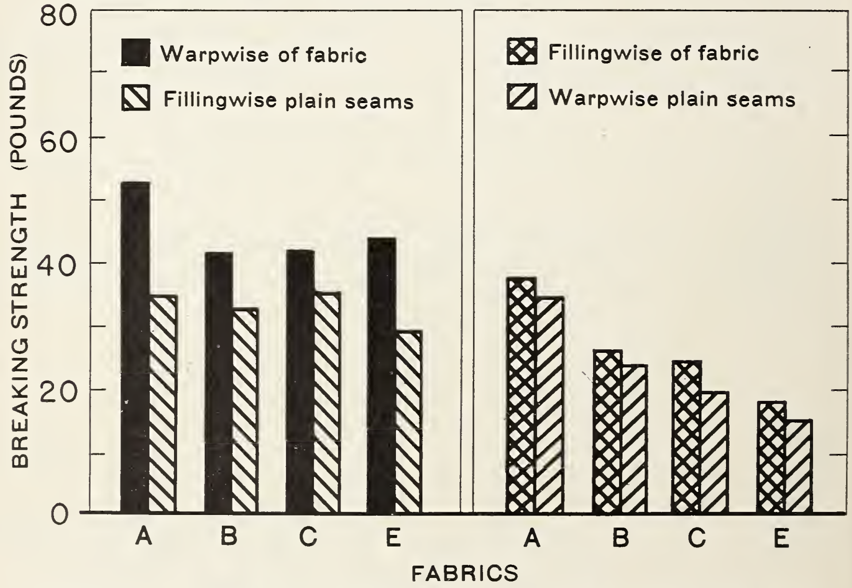

FIGURE 14.—Comparison of strength of plain seams made fillingwise on high- (A), medium- (B and C), and low-count (E) fabrics with warp strengths of the respective fabrics, and of seams made warpwise with the filling strengths of the respective fabrics.

(fig. 15). However, the strength of fillingwise seams was less regularly affected by the three fabrics.

When the high-, medium-, and low-count fabrics were used for plain, lapped, French, standing fell, and stitched fell seams made fillingwise, the strengths of the seams on the respective fabrics

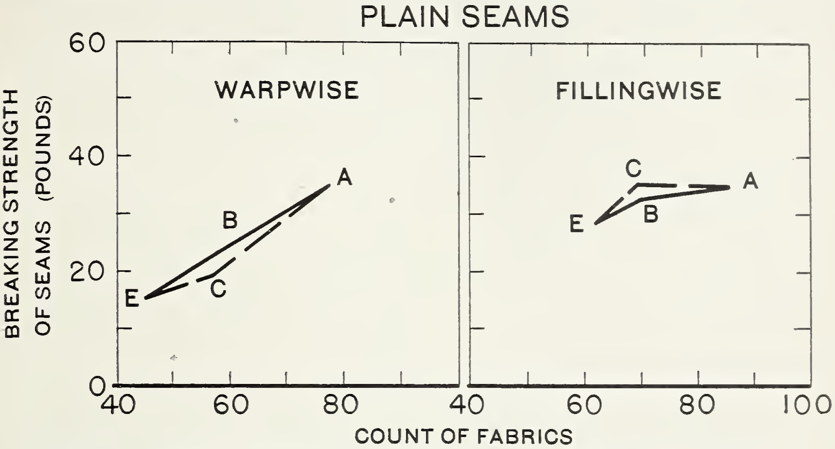

Figure 15.—Relationship of strength of plain seams made warpwise on high- (A), medium- (B and C), and low-count (E) fabrics with filling counts of the respective fabrics; and of seams made fillingwise with the warp counts of the respective fabrics.

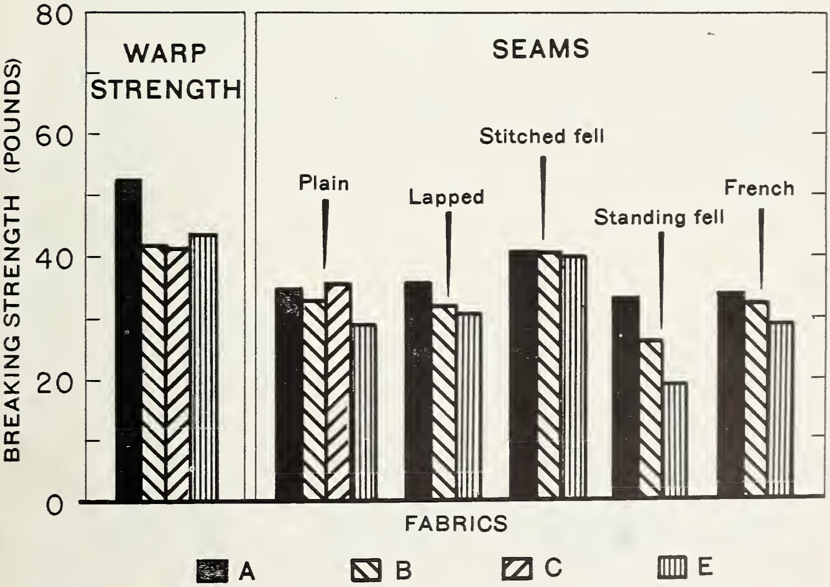

Figure 16.—Comparison of breaking strength of plain, lapped, stitched fell, standing fell, and French seams made fillingwise with 11 stitches per inch and 3-cord mercerized 50 thread, on high- (A), medium- (B and C), and low-count (E) fabrics with the warp strength of the respective fabrics.

ran from high to low, with one exception (fig. 16). With the stitched fell seam (the strongest of all), only small differences in strength were associated with the fabrics of different counts, but with the standing fell seam (the weakest of all) strength differences associated with the different fabrics were significantly great. For French and lapped seams, some of the strength differences associated with count of fabric were significant. For plain seams

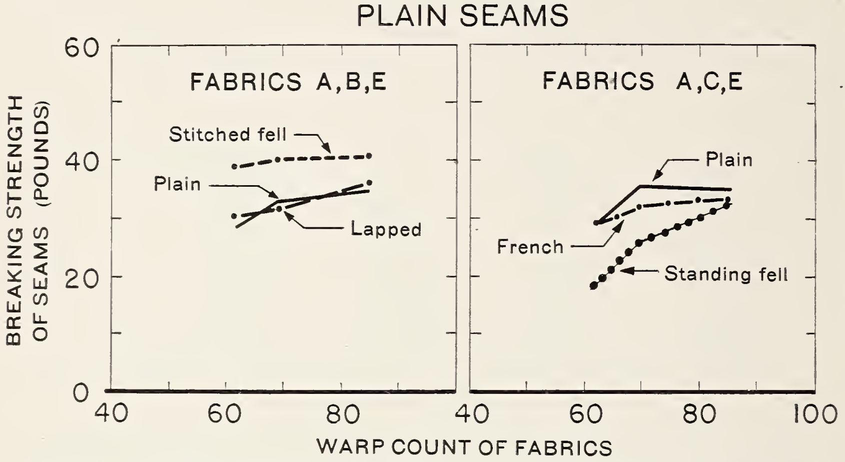

FIGURE 17.—Relationship of strength of plain, lapped, stitched fell, standing fell, and French seams made fillingwise on high- (A), medium- (B and C), and low-count (E) fabrics to the warp count of the respective fabrics.

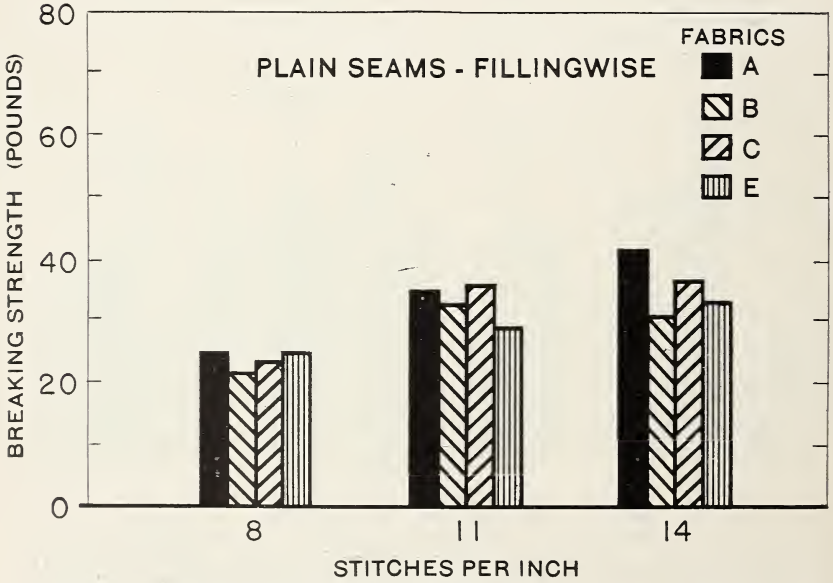

FIGURE 18.—Comparison of breaking strength of plain fillingwise seams made with 8, 11, and 14 stitches per inch on high- (A), medium- (B and C), and low-count (E) fabrics, 3-cord mercerized 50 thread.

made from high-, medium-, and low-count prints A, B, and E, respectively, the strengths ran from high to low. The relation between the count of the qualities of fabrics and the breaking strength of seams made from them is shown in figure 17.

The different fabrics had relatively little effect on the breaking strength of plain fillingwise seams when 8 stitches per inch were used (fig. 18). However, with 11 and 14 stitches per inch, the strengths of seams on the high-count print were consistently higher than those on the low-count, while the strengths of seams on the medium-counts were sometimes higher, and in one case lower, than those on the low-count.

The fabric was an unimportant factor in the breaking strength of plain fillingwise seams made with the 6-cord unmercerized thread 50 (fig. 19). When stitched with 3-cord mercerized thread 50, seams on the high-count print were stronger than those on the low-count fabric. The reverse was true when the seams were stitched with 2-cord 00 mercerized thread—the seams on the high-count being slightly weaker than those on the low-count print.

BREAKING-STRENGTH FINDINGS COMPARED WITH THOSE OF PREVIOUS STUDIES

The extent to which the seams in this study would meet Edgerton's minimum standard of 20 pounds (*7*) is shown in figures 3 to 12, and 16. In the preliminary study, all five kinds of seams in the fillingwise and armscye positions were equal to or surpassed 20 pounds, as were also all kinds of seams made fillingwise on the high-, medium-, and low-count fabrics except the standing fell

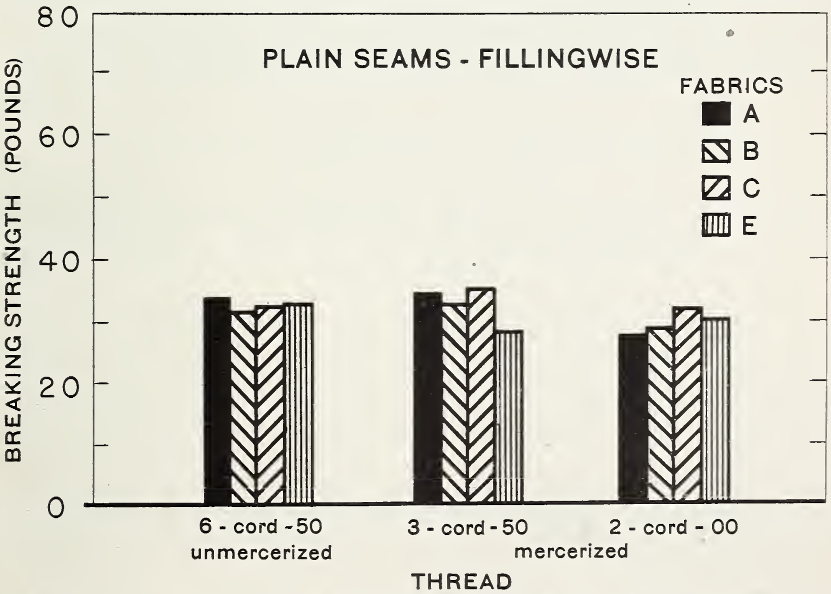

Figure 19.—Comparison of breaking strength of plain fillingwise seams made with 6-cord unmercerized 50, 3-cord mercerized 50, and 2-cord mercerized 00 thread on high- (A), medium- (B and C), and low-count (E) fabrics, with 11 stitches per inch.

seams on the low-count print. Stitched fell seams in all positions were stronger than 20 pounds. Strengths lower than 20 pounds were found particularly in plain, French, and standing fell seams in warpwise, skirt, and hip positions from medium- and low-count prints C and E, and in plain and lapped seams in the same positions made from medium-count print B. Some of these seams were also weak when made in the shoulder position. The stitched fell was the only seam that, in any instance, withstood the tension of 40 pounds that, according to Williams' estimates, ordinarily occurs in garments (*23*).

The stitched fell seams in the present study, as well as the plain seams in the study by Keeney, Watson, and Thompson (*11*) indicated that 8 stitches per inch gave satisfactory strength to armscye seams with two rows of stitching, if the 20-pound criterion is used for minimum breaking strength. Likewise, the statement of these workers that 12 to 15 stitches per inch gave greater strength was confirmed to the extent that in the group of seams with 25 pounds or more strength, the proportion with 14 stitches per inch was larger than the proportion with 8 or 11 stitches per inch.

In general, the data substantiated Lewis' statement that seamed fabrics are weaker than seamless ones under the best conditions of stitching (*13*). This generalization held true for all plain, standing fell, and lapped seams and for some of the stitched fell seams. However, the strength of six of nine stitched fell warpwise seams on fabric B was higher than the fillingwise strength of the fabric, and in the other three cases there was less than 1 pound difference between the seam strength and the fabric strength. In two other cases, the stitched fell seams made fillingwise were less than 1 pound weaker than the warp strength of the unseamed fabric.

Stitched fell seams were superior in strength to plain and French seams in the present study, as well as in that by Williams (*23*).

EFFECT OF VARIANTS ON ELONGATION OF SEAMS AT POINT OF BREAK

All the variants were highly significant in their effect on the elongation of seams at point of break, although some were more important than others (table 20).

Direction of Fabric Yarns in Relation to Seams.—The direction of the seams in relation to warp and filling yarns was by far the most important source of variation in elongation of seams at point of break in the first phase of the study, as was the case for the breaking strengths. Armscye seams had greater elongation than those in other locations in a large number of instances, probably because the lower back curve in the armscye and sleeve approximates the direction of true bias, which is noted for elongation. Fillingwise seams elongated relatively little compared with seams in other positions, probably because of the low warpwise elongation of the fabric.

Size of Stitch and Kind of Seam and Thread.—In general, the effects of size of stitch and kind of seam and thread upon elongation of the seams at point of break were less than the effect

Table 20.—*Analysis of variance for elongation of seams; medium-count fabrics B, C, and D*

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Kind of seam-fabric (S)	5	2.2650	0.4530	**171.45
Direction of seam (D)	5	121.2846	24.2569	**9180.27
Kind of thread (T)	2	.1772	.0886	**33.54
Length of stitch (L)	2	.9534	.4767	**180.42
S × D	25	2.1760	.0870	**32.94
S × T	10	.1161	.0116	**4.39
S × L	10	.3058	.0306	**11.57
D × T	10	.1246	.0125	**4.72
D × L	10	.4192	.0419	**15.87
T × L	4	.0160	.0040	1.51
S × D × T	50	.2623	.0052	**1.99
S × D × L	50	.3758	.0075	**2.85
S × T × L	20	.1414	.0071	**2.68
D × T × L	20	.1417	.0071	**2.68
S × D × T × L	100	.4307	.0043	**1.63
Experimental error	2,916	7.7050	.0026	
Total	3,239	136.8930		

**Significant at 1-percent level.

of direction of the fabric yarns in seams. Elongation tended to decrease slightly as the number of stitches per inch increased. It tended to be greater for French seams than for other types. Thread was the least important source of variation in elongation. Seams with 6-cord unmercerized 50 thread tended to have greater elongation than those made with 3-cord 50 or 2-cord 00 mercerized threads.

Fabric.—When fabrics of different counts were used elongation of seams differed significantly in only about one-third of the tests. In most of them, seams on the high-count fabric had greater elongation than those on the medium- and low-count prints. These results follow in line with the elongation of the fabrics.

RELATION OF VARIANTS TO DAMAGE TO THREAD OR FABRIC AS A RESULT OF THE BREAK

The types of damage that accompanied the break of the specimen included the rupture of the fabric at or away from the seam, the slippage of the fabric yarns, and the breaking of the thread in the stitching (fig. 19).

Direction of Fabric Yarns in Relation to Seams.—In the first phase of the study, specific types of damage tended to be associated with some directions of seams, particularly in some kinds of seams. For example, with fillingwise seams, thread breaks predominated except for the stitched fell seams, in which the fabrics usually broke. The same general relationship held for shoulder seams, except that there were more thread breaks with stitched fell shoulder seams than with stitched fell fillingwise seams.

In warpwise, skirt, and hip locations, fabric breaks occurred in all types of seams except standing fell seams, where the narrow edge frequently pulled completely from the seam. In the armscye position, breaks usually occurred parallel to the warp yarns, the breaks running from the seam diagonally to the edge of the specimen. In this location, no thread breaks occurred with stitched fell seams, and complete slippage (that is, the narrow edge pulled entirely out of the seam) occurred with standing fell seams less frequently than elsewhere. In all positions except the shoulder and armscye, some visible slippage commonly occurred at seams, although, according to the standard method of test, there was no measurable slippage in fabrics C and D.

KIND OF SEAM.—The high strength of stitched fell seams was associated with a marked tendency for the fabric to break. The high proportion of fabric breaks was apparently due to the fact that the strength of the seams was high in relation to the fabric strength.

Standing fell seams showed complete slippage of yarns to a more marked degree than did any of the other kinds of seams. The reason for this is probably twofold: The narrow seam allowance on half of the seam held by only one row of stitching; and the properties of some of the fabrics.

With plain, lapped, and French seams in fillingwise and shoulder positions, thread breaks occurred most often; in warpwise, hip, skirt, and armscye positions, fabric breaks occurred frequently. In fillingwise and shoulder positions, the seam strength was considerably less than the warp strength of the fabrics; therefore, the thread broke. In the other positions, the seam strengths frequently approached the fabric strength and fabric breaks resulted.

SIZE OF STITCH.—As the number of stitches per inch increased fabric breaks tended to be more frequent, particularly at the seam, and thread breaks less frequent except in standing fell seams. This relationship existed whether or not the strength tended to increase with an increasing number of stitches per inch, as in fillingwise and shoulder seams, or to decrease with increasing stitches per inch, as in warpwise, hip, and skirt seams. In general, complete slippage was more frequent in standing fell seams as the number of stitches per inch increased. This tended to hold true for all seams where slippage occurred (fig. 20). These findings were contrary to Williams' theory that a low number of stitches per inch might contribute to slippage (*22*).

THREAD.—Thread breaks were relatively few when seams were stitched with 6-cord unmercerized 50 thread (350 out of 1,251 breaks), and most numerous when stitched with 2-cord mercerized 00 thread (473 out of 1,251 breaks). The tendency for the smaller number of thread breaks to occur with 6-cord unmercerized 50 thread was most apparent with 8 stitches per inch, particularly in the warpwise, skirt, hip, and armscye position. The occurrence of thread breaks in the seams and the breaking strength of seams

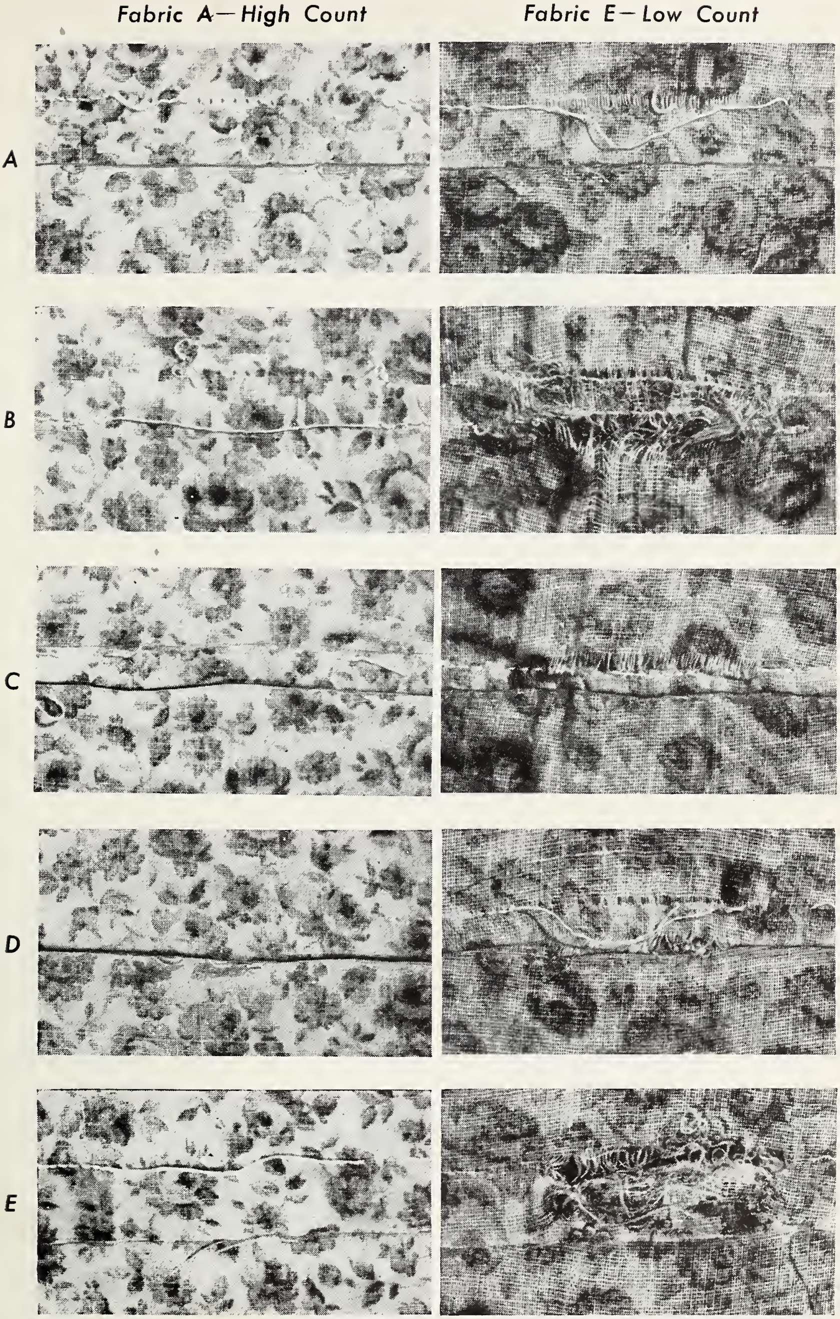

FIGURE 20.—Broken seams made with 14 stitches per inch on high- and low-quality fabrics: *A*, plain; *B*, stitched fell; *C*, standing fell; *D*, French; *E*, lapped.

appear to be related since the thread that gave the greatest strength to seams broke less frequently than the other threads.

Fabric.—The count of fabric often appeared to be related to the type of damage—fabric damage tended to be more frequent and more severe with low-count than with high-count fabrics (fig. 20). There were appreciably fewer cases of fabric damage in the high-count print than in the medium- and low-count prints for warpwise plain seams and stitched fell seams with 11 stitches per inch, and for fillingwise plain seams with 14 stitches per inch. With standing fell seams, complete slippage occurred whenever medium- and low-count prints were used, but with high-quality prints, only thread breaks occurred. With French and lapped seams, the quality of fabric made relatively little difference in the kind of damage.

The count of the fabric was related to the kind of damage in some of the plain seams made warpwise and fillingwise. In plain warpwise seams fabric breaks occurred with the low- and medium-count prints but not with the high-count material. With plain fillingwise seams, thread breaks occurred in the seams in all the prints. In addition, almost complete slippage, together with only a few thread breaks, occurred with every warpwise seam on low-count print, while thread breaks were more frequent for the warpwise seams on the high-count print.

When plain fillingwise seams were made with 8, 11, and 14 stitches per inch, thread breaks always resulted with fabrics A, C, and E, but not with B. Fabric damage occurred more frequently with 14 stitches per inch, especially with fabrics B, C, and E.

The count of the fabric had little relation to the kind of damage to seams stitched with the different kinds of thread. The predominant type of damage was a thread break.

STRENGTH AT PATCH POCKET CORNERS

Patch pockets frequently tear from utility garments because of sudden strong pulls or jerks, or recurring strains. Despite the widespread occurrence of patch pocket failures, no studies have been reported on factors that affect the durability of patch pocket attachment. However, sometimes reasons are given in references for suggesting particular methods of fastening pockets to garments. Cook stated that ". . . the use of the oblique line at the corners protects that part from the strain of hands thrust hurriedly into the pocket, by distributing the force of the strain" (*5*). For a patch pocket on a house dress, Scott suggested top corners that are barred (boxed) with stitching and a tape stay—a reinforcement that gives greater protection against accidental tears (*16*).

References on clothing construction recommend several methods for attaching patch pockets (*2, 3, 4, 5, 6, 12, 16, 17, 19, 20*). Each method shown in figure 21 (except methods *B* and *G*) was suggested in one or more texts consulted. Other methods mentioned were invisible hand stitching, stitching carried to the top, and reinforcement of tape or cloth.

METHODS OF ATTACHING PATCH POCKETS IN READY-MADE HOUSEWORK DRESSES

To determine how patch pockets are attached to ready-made housework dresses, 208 garments were examined. Observations were made on 164 dresses in stores in Columbus, Ohio, and on 44 dresses bought in Washington, D. C., and in New York City in 1945. All were priced below $10. Retraced stitching was found most often; extended stitching, in a number of dresses (fig. 21). Sometimes the retraced stitching was carried beyond the pocket

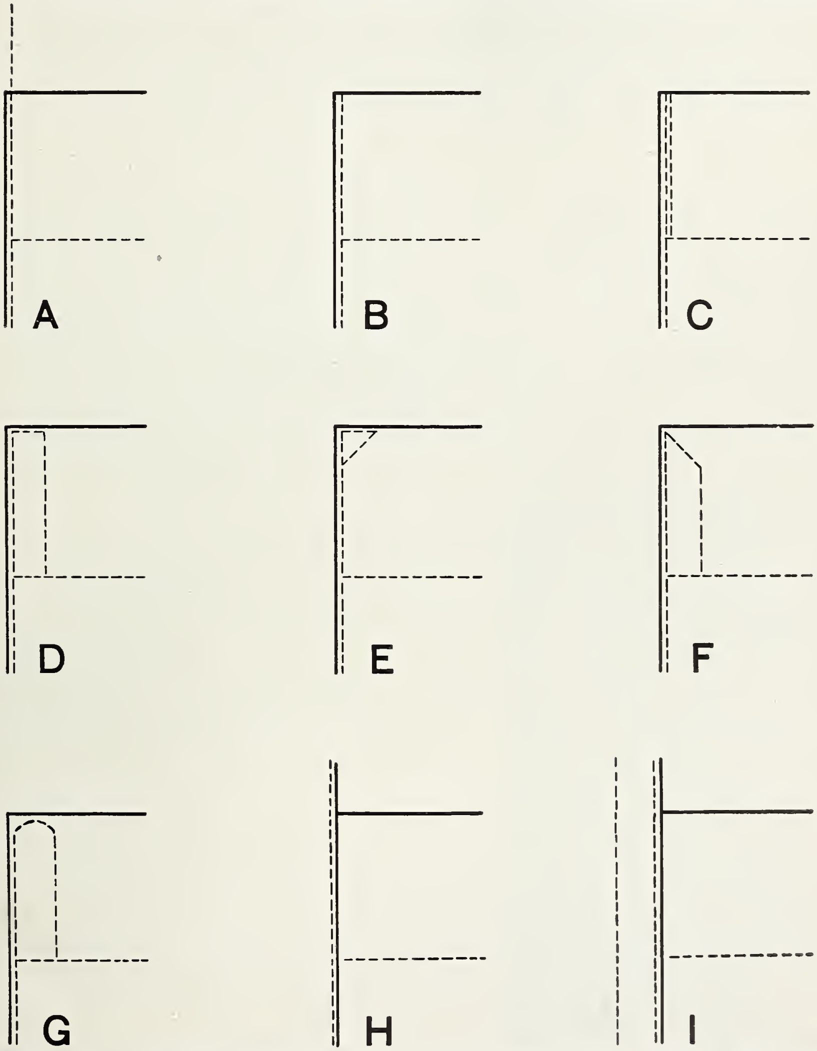

FIGURE 21.—Ways of attaching patch and modified patch pockets. Stitching patterns: *A*, Extended; *B*, tied thread ends; *C*, retraced; *D*, rectangular; *E*, triangular; *F*, diagonal; *G*, curved; *H*, set into a lapped seam, single-stitched; and *I*, double-stitched.

top and sometimes stopped short of it. Some dresses had pockets finished with tied thread ends and with rectangular and triple stitching; some pocket corners had unfinished thread ends. In a few dresses, different methods of stitching were used for corners of the same pocket. On several garments, the pockets were modified by having one or both sides or a part of the top inserted in a seam.

Mercerized 2-cord thread was used for sewing pockets on most of the dresses; 3-cord mercerized for the rest. The number of stitches per inch ranged from 7 to 11 for the dresses studied in Ohio, with the majority having from 8 to 10 stitches per inch. There was a tendency for the number of stitches per inch to be increased with the price of these dresses. In the dresses purchased by the Bureau, the range was from 8 to 15 stitches per inch; about two-thirds of the dresses had from 8 to 12 per inch.

Experimental Procedure

The first phase of the study of strength at patch pocket corners included four variables: Pattern of corner stitching, fabric, size of stitching (number of stitches per inch), and thread. The patterns of corner stitching used were retraced (fig. 21, *C*) and rectangular (fig. 21, *D*)—two of the patterns most frequently mentioned in the references consulted on clothing construction—and extended (fig. 21, *A*) stitching, a pattern of stitching often found on ready-made dresses. Pockets were cut from three cotton prints with different counts (table 1, F, H, and I) stitched with 8, 11, and 14 stitches per inch, with four kinds of thread—6-cord and 3-cord unmercerized 50, and 2-cord 00 and 3-cord 50 mercerized (table 6).

Results from the first phase of the study led to a critical examination of the effect of four additional patterns of stitching: (1) Tied thread ends—that is, threads from the stitching at the top of the pocket pulled to the wrong side, tied, and clipped to ½ inch; (2) triangular stitching; (3) diagonal stitching; and (4) curved stitching (fig. 21, *B, E, F,* and *G*). Pockets with these as well as with retraced, extended, and rectangular stitching were made from bleached muslin, the physical properties of which resembled somewhat those of the high- and medium-quality prints. Stitching was made with 6-cord unmercerized 50 thread, 14 stitches per inch.

Other phases of the study covered the effect of reinforcement under pocket corners stitched with diagonal stitching, and the effect of modifying typical patch pocket construction by enclosing the sides of the pocket in lapped seams with single (fig. 21, *H*), and with double stitching (fig. 21, *I*). For these two parts of the study medium-count print G (table 1) was used. Stitching was made with 6-cord unmercerized 50 thread, 14 stitches per inch.

MAKING TEST POCKETS

A 30-yard length of each fabric was divided into ten 3-yard pieces. From each piece a sufficient number of pockets and background pieces was cut so that each combination of factors was represented once. Likewise, one determination for each physical property of the new fabric was made from each piece. Thus ten replications were provided for pockets with each variation and for each physical property of the fabric.[4] Pockets and backgrounds were paired at random.

The patch pockets were cut 5½ inches wide (fillingwise) and 5¾ inches long (warpwise); the backgrounds, 7 by 9 inches. The top of each pocket was finished with a ¾-inch hem, made by folding the top down 1 inch and then turning under the cut edge ¼ inch. The hems were basted and then stitched with the same kind of thread and size of stitch to be used in applying the pockets to the backgrounds. The three remaining raw edges of the pocket were turned under ¼ inch, and the pockets basted and stitched to the backgrounds in the position shown in figure 22, with the patterns of corner stitching shown in figure 21, *A* to *G*. The number of stitches used at the corners is given in table 21.

For the modified patch pockets, the pocket pieces were cut 6 inches fillingwise and 5¾ inches warpwise. The background consisted of one center piece 6 inches fillingwise and 9 inches warpwise, and two side strips each 1½ inches fillingwise and 9 inches warpwise. The hems were folded and stitched as for patch pockets. The bottom edge of each pocket was folded under ¼ inch and stitched to the center piece 1 inch above the lower edge. One long edge of each side section was turned under ½ inch, the folded edges basted over the center section and pocket to make lapped seams ½-inch wide, and stitched (fig. 21, *H* and *I*). The two rows in *I* were approximately ¼ inch apart.

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[4] All tests of fabric, thread, and pocket specimens were conducted under standard test conditions (*1*).

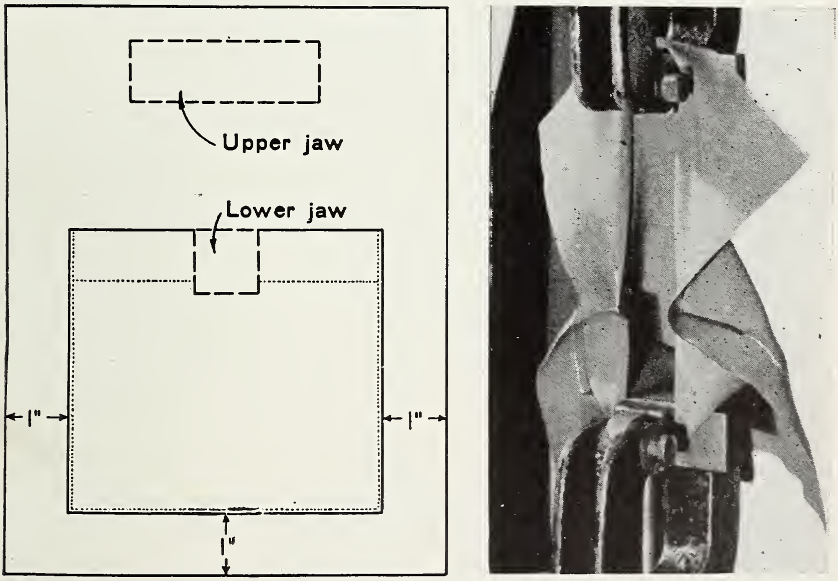

FIGURE 22.—Patch pocket specimens: *Left*, Diagram of pocket, showing upper and lower jaws of strength tester; *right*, test specimen in process of being broken.

TABLE 21.—*Approximate number of stitches in patterns of stitching at pocket corners*

Patterns of stitching	Number of stitches at corner	Number of stitches per inch
Extended	4	8
	6	11
	7	14
Retraced	6	8
	8	11
	11	14
Rectangular	2	8
	3	11
	3	14
	6	8
	8	11
	11	14
Triangular	3	14
	4	14
Diagonal	4	14
	9	14
Curved	4	14
	9	14

All stitching was made with a lock-stitch, family-type sewing machine having an oscillating shuttle. The needle was the recommended size for 50 thread. Adjustments for length of stitch were acceptable when an average of five readings, 1 inch apart, was within ±½ stitch of the desired number.

BALANCING TENSIONS ON STITCHING THREADS

Lacking standardized procedures for achieving balanced tension on the upper and lower threads, one or more of the following techniques were used, singly or in combination, to evaluate the balance:

VISUAL INSPECTION.—Visually the tensions on the threads in the stitching were considered satisfactory when the threads interlocked in the fabric and not on the upper or under surface, and the stitching did not pucker the fabric.

BIAS STITCHING.—The bias stitching test, described by Holbrook and Krewatch (*10*), was another means for determining whether the tension on one thread was greater than on the other. Stitching made along the true bias of the fabric was gripped between the thumb and forefinger of each hand (with the thumbs 1 inch apart) and pulled. If one thread broke before the other, the tensions were adjusted until both threads broke simultaneously.

MEASUREMENT OF CRIMP IN THREADS IN STITCHING.—An experimental method was devised to determine balance of tension by means of crimp in the threads as stitched in the fabric.[5] Parallel rows of stitching were made on two thicknesses of fabric. A 10-cm. length was marked on each row and the stitching carefully removed. The threads were straightened by means of a constant weight, and the distances between the marks measured. The tensions were considered in balance when the lengths of the upper and under thread differed nor more than ±0.15 cm.

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[5] Method devised by Fletcher and Whitlock.

MEASURING TENSION

A tensometer was used to determine the tension on sewing thread at different stages in the threading process. At first the thread was pulled through the tensometer by hand, but later a motor-driven device operating at a constant speed was used.

When the hand-operated tensometer was used in connection with the upper thread (fig. 23, top) the tension force was recorded after the thread was carried over the take-up spring. The presser foot was lowered, the tensometer held in front of the take-up spring, and the thread pulled smoothly through the tensometer.

With the motor-driven tensometer, the upper thread was carried between the tension discs, then drawn counterclockwise toward the

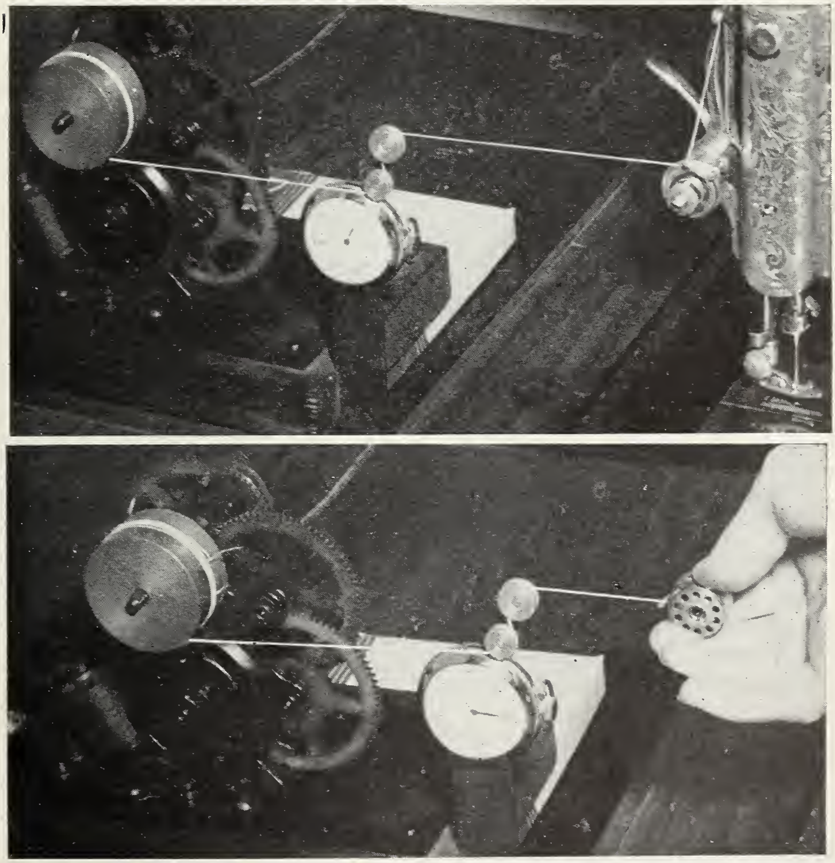

FIGURE 23.—Tensometer and motor-driven winding device used for measuring the tension force: *Top*, on the upper thread at a convenient stage in threading; *bottom*, on the lower thread.

back of the machine, through the tensometer, and fastened to a drum. The drum was 16 cm. in circumference and turned at a rate of four revolutions per minute, a speed approximating that at which the thread usually moved through the machine for stitching in this study. To measure the force on the lower thread, the bobbin case was held in the hand so that the thread was carried in the same relative position as when stitching (fig. 23, bottom). After each determination of tension on the thread, the motor was stopped before succeeding measurements were made.

EVALUATING METHODS OF ATTACHING PATCH POCKETS

Methods of attaching patch pockets were evaluated by means of breaking strength determinations, elongation at time of rupture, and by the effect of the rupture of the specimen upon the pocket itself, the background fabric, and the stitching.

Breaking Strength Determinations.—The breaking strength at pocket corners was determined with a standard fabric tester, using a 3-inch front upper clamp and a 1-inch front lower clamp. The distance between the jaws and the speed of operation were the same as those used for breaking strength determinations of fabric. The areas indicated by arrows on the background fabric and on the pocket (fig. 22) were fastened in the upper and lower jaws, as shown in figure 22.

While the breaking strength determinations were being made, an operator noted when the first break occurred, another marked the point of break on the curve of the elongation chart, and a third read the dial. This procedure was followed because rupture continued even after the initial break.

Elongation Determinations.—Each reading of elongation was taken from the point at which the curve departed from the zero axis for breaking strength to the point of break. Elongation measurements were made to the nearest one-eighth inch.

Effect of Rupture at Pocket Corners.—A qualitative judgment was made on the damage resulting from the breaking-strength determinations, and on the relations of the variants to the types of damage. This was done as a basis for evaluating the desirability of the variants for patch pocket construction.

Statistical Measures.—To compare the effect of all variants, an analysis of variance was used. The *t* test was employed to evaluate differences between means of breaking strength and of elongation determinations at the 1-percent and 5-percent levels. The relationship between breaking strength and elongation at pocket corners was determined by means of correlation coefficients.

Results

EFFECT OF VARIANTS ON BREAKING STRENGTH AT POCKET CORNERS

All four variables included in the first phase of the study were highly significant sources of variation in the breaking strengths at pocket corners (table 22). The pattern of corner stitching was the most influential of the variants. Fabric, length of stitch, and thread ranked next in descending order. The discussion of the effect of these factors is followed by the analysis of the effect of tape reinforcement and modification of patch pocket construction.

PATTERN OF CORNER STITCHING.—Rectangular stitching, in general, gave greater strength at pocket corners than did retraced or extended stitching (fig. 24). The rectangular pattern was significantly stronger more often for pockets made from the medium- and low-count prints H and I than for pockets made from the high-count print F. For some of the pockets made from the high-count print, retraced stitching gave significantly greater strength than did the rectangular stitching.

Most of the pockets with extended stitching were stronger than those with retraced stitching when made from the medium- and low-count prints, but the relationship was reversed when pockets were made from the high-count print.

The strength contributed by each of the seven patterns of stitching is shown in figure 26. Diagonally stitched corners were markedly stronger than the others, being four times as strong as those with retraced stitching and almost twice as strong as those with rectangular stitching. The breaking strengths at corners with the various stitching patterns were significantly different from one another at either the 5- or 1-percent levels, with the exception of the three that were very close in strength—tied thread ends and extended and triangular stitching (table 23). The superiority of the diagonal stitching corroborates Cook's opinion (*5*).

FABRIC.—Pockets made from the high-count print had the strongest corners in 68 percent of the tests. The differences in strength between pockets made from the high-count print and those made on the medium- and low-count materials were significant in 46 percent of the tests. This superiority of pockets made from the high-count print is logical in light of the physical properties of the fabrics (table 1).

The influence of the high-count material was most marked for pockets made with retraced stitching, irrespective of the number of stitches per inch used (fig. 25). On the other hand, with rectangular stitching the influence of the high-count print was most marked when 14 stitches per inch were used. Quality of fabric had little effect on the strength of pocket corners with extended stitching.

LENGTH OF STITCH.—The effect of the number of stitches per inch can be seen in figures 24 and 25. Differences in breaking strength at pocket corners associated with change in size of stitch tended to be small. They were significantly large in only 49 of the 108 tests. In the largest number of the significant instances, stitching with 11 or 14 stitches gave greater strength at corners than that with 8 stitches per inch.

KIND OF THREAD.—The effect of kind of thread, even though significant, was considerably less than that of pattern of stitching, fabric, or size of stitch. In only 17 percent of 162 tests were the differences significant. Of these, approximately half were in the

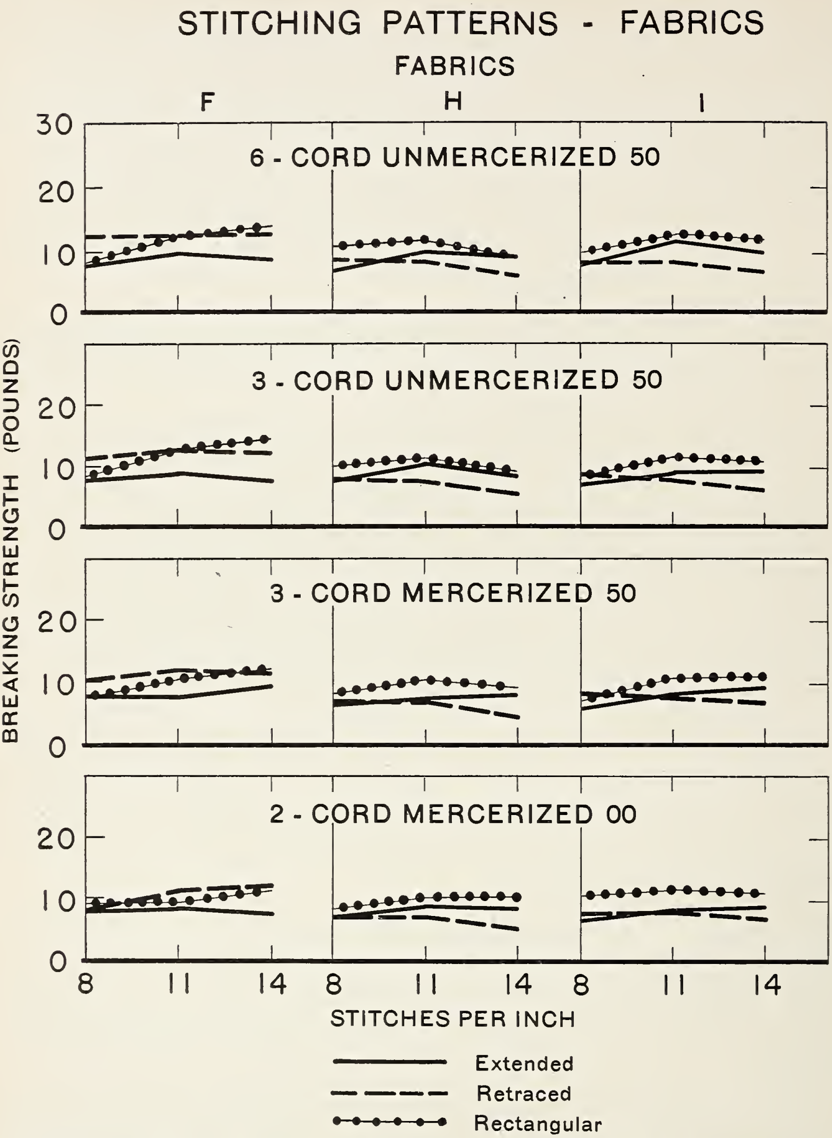

FIGURE 24.—Effect of pattern of stitching on breaking strength at corners of pockets made from fabrics with different counts.

group in which 6-cord unmercerized 50 thread gave greater strength at corners than the 3-cord unmercerized 50 thread, the 3-cord mercerized 50 thread, or the 2-cord mercerized 00 thread. Each of the last three threads gave superior strength in a few instances. The size of stitch was the only variant that may have had some relationship to the kind of thread, but the relationship was not pronounced.

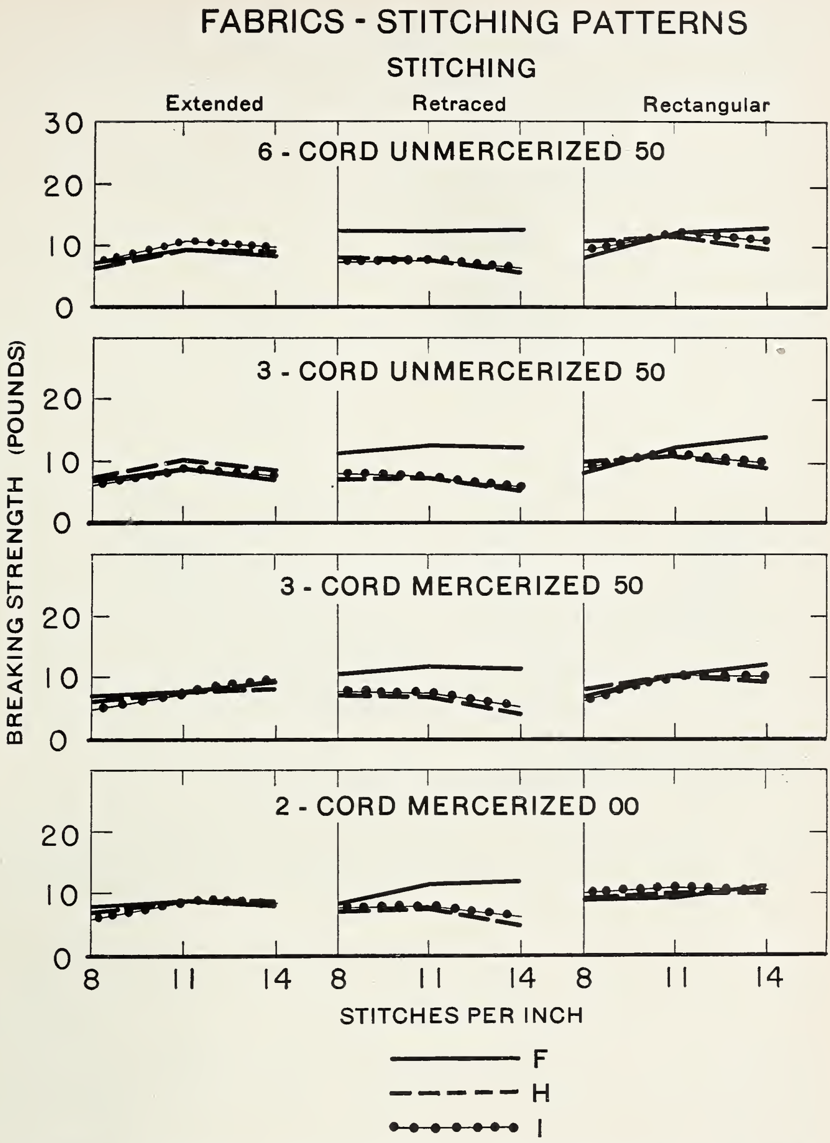

FIGURE 25.—Effect of quality of fabric on breaking strength at corners of patch pockets made from fabrics with different counts.

TAPE REINFORCEMENT.—When a tape reinforcement was used with the diagonal pattern of stitching for pockets made from print G, a medium-count fabric, the strength of the reinforced corners was 1⅓ times as great as that of similar corners without reinforcement (fig. 26). This significantly greater strength for reinforced corners affirms Scott's statement that reinforcement gives protection against accidental tears (*16*).

TABLE 22.—*Analysis of variance for breaking strength at patch pocket corners; three patterns of stitching, three numbers of stitches per inch, four kinds of thread, three counts of fabric*

Sources of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	2	829.57	414.79	**76.17
Blocks of same fabric	27	147.04	5.45	
Stitching pattern (P)	2	1,000.27	500.14	**187.10
Kinds of thread (T)	3	126.85	42.28	**15.82
Length of stitches (L)	2	358.31	179.16	**67.02
F × P	4	1,000.66	250.16	**93.59
F × T	6	32.40	5.40	2.02
F × L	4	191.06	47.76	**17.87
P × T	6	18.68	3.11	1.16
P × L	4	291.69	72.92	**27.28
T × L	6	38.18	6.36	*2.38
F × P × T	12	90.17	7.51	**2.81
F × P × L	8	216.74	27.09	**10.14
F × T × L	12	34.06	2.84	1.06
P × T × L	12	101.28	8.44	**3.16
F × P × T × L	24	80.06	3.34	1.25
Sub-block treatments × whole blocks of same fabric	[1] 941	2,515.36	2.67	
Total	1,075	7,072.38		

*Significant at 5-percent level.
**Significant at 1-percent level.
[1] Four degrees of freedom subtracted for estimated values.

TABLE 23.—*Significance of differences between mean breaking strengths at corners of muslin patch pockets with seven patterns of stitching, as indicated by* t *values*

Type of stitching at pocket corner	Retraced	Triangular	Extended	Tied ends	Rectangular	Curved	Diagonal
Retraced		*2.839	**3.381	**4.080	**6.295	**10.179	**15.196
Triangular			1.179	1.824	**4.985	**9.681	**15.586
Extended				.373	**3.549	**7.628	**13.307
Tied ends					**3.520	**7.967	**13.933
Rectangular						**3.562	**9.174
Curved							**6.048

*Significant at 5-percent level. **Significant at 1-percent level.

LAPPED SEAMS AT SIDES OF MODIFIED PATCH POCKETS.—When patch pockets were modified in construction by having the sides inserted in lapped seams with single or with double stitching, the number of rows of stitching did not significantly affect the breaking strength at the corners (table 24).

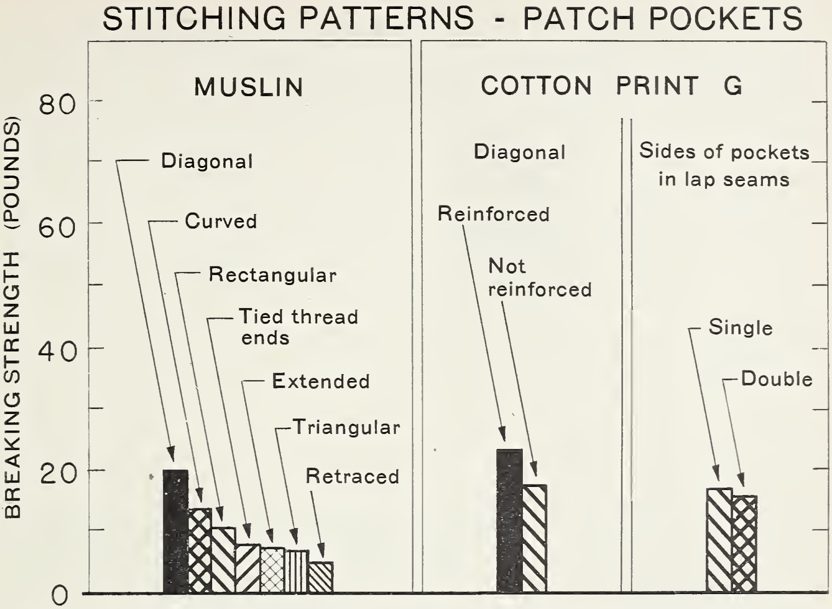

FIGURE 26.—Effect on breaking strength at patch pocket corners of pattern of stitching on muslin pockets, of reinforcing diagonally stitched corners with tape, and of modifying patch pocket construction by inserting sides in lapped seams with single and with double stitching.

The modified pockets were weaker than regular patch pockets made from the same material with diagonally stitched corners, and significantly weaker than those with reinforced diagonal corners, but stronger at the corners than any of the pockets made with the other six patterns of stitching (fig. 26).

EFFECT OF VARIANTS ON ELONGATION AT POCKET CORNERS

The four variants used in determining factors affecting the breaking strength at patch pocket corners had highly significant influences on elongation at point of break (table 25). The variants ranked in descending order as follows: Length of stitch, fabric, thread, and pattern of stitching. With the exception of the place of fabric, this order differs from that for the effect of the same variants upon breaking strength (p. 46).

LENGTH OF STITCH.—In general, 8 or 11 stitches per inch resulted in greater elongation at pocket corners than did 14 stitches per inch. Differences in patterns of stitching, count of fabric, and type of thread seemed to have little bearing on the exceptions to the generalization.

Significantly greater elongation was found at corners with 8 than with 11 or 14 stitches per inch in 54 percent of the 72 tests. Corners with 11 stitches per inch had significantly greater elongation than those with 14 stitches in 75 percent of 36 comparisons.

TABLE 24.—*Significance of differences between mean breaking strengths at corners of patch pockets, diagonally stitched, with and without reinforcements, and at corners of modified patch pockets, as indicated by* t *values*

Type of stitching at pocket corner	Diagonal stitching		Modified patch pocket (sides set in lapped seams)	
	Not reinforced	Reinforced	Double stitching	Single stitching
Diagonal:				
Not reinforced	----------	**4.440	1.689	0.916
Reinforced	----------	----------	**6.596	**5.553
Sides in lapped seams:				
Double stitching	----------	----------	----------	.671

**Significant at 1-percent level.

TABLE 25.—*Analysis of variance of elongation at point of break at patch pocket corners made with three patterns of stitching, three numbers of stitches per inch, four kinds of thread, and three counts of fabric*

Sources of variation	Degrees of freedom	Sum of squares	Mean square	F
Fabrics (F)	2	1.6414	0.8207	**74.30
Blocks of same fabric	27	.2982	.0110	----------
Stitching pattern (P)	2	.1649	.0825	**8.40
Kinds of thread (T)	3	.4494	.1498	**15.41
Length of stitches (L)	2	4.0917	2.0459	**210.39
F × P	4	1.9673	.4918	**50.58
F × T	6	.0776	.0129	1.33
F × L	4	.2425	.0606	**6.23
P × T	6	.3690	.0615	**6.32
P × L	4	.2870	.0718	**7.38
T × L	6	.1755	.0293	**3.01
F × P × T	12	.1566	.0131	1.34
F × P × L	8	.1827	.0228	*2.35
F × T × L	12	.2344	.0195	*2.01
P × T × L	12	.4725	.0394	**4.05
F × P × T × L	24	.4345	.0181	**1.86
Sub-block treatments × whole blocks of same fabric	[1] 941	9.1505	.0097	----------
Total	1,075	20.3959	----------	----------

*Significant at 5-percent level. **Significant at 1-percent level.

[1] Four degrees of freedom subtracted for the four estimated values.

FABRIC.—On the whole, elongation tended to be greatest for the pockets made from the medium- and high-count prints and least for those made from the low-count print. This generalization held true regardless of the thread used, but there were exceptions in connection with the different patterns of stitching and with length of stitch.

THREAD.—On the basis of significant effect upon elongation at pocket corners, the threads ranked, in descending order, as follows: 6-cord unmercerized 50; 3-cord unmercerized 50; 2-cord mercerized 00; and 3-cord mercerized 50. In the group with significant differences in elongation, the stretch was greater for pockets stitched with 6-cord and 3-cord unmercerized threads than for those sewed with 2-cord and 3-cord mercerized threads in 49 percent of the cases. The reverse was true in 20 percent of the instances.

PATTERN OF CORNER STITCHING.—Of the three patterns of stitching included in the first phase of the study, retraced stitching resulted in slightly greater elongation at pocket corners than did the rectangular and extended stitching patterns. This slight superiority was due chiefly to the relatively high values for elongation of retraced stitching on fabric F.

For the muslin pockets with the seven patterns of stitching, a highly significant correlation (0.95) was found between breaking strength and elongation. Elongation was markedly greater for pockets with diagonal stitching than for those with other patterns (table 26).

REINFORCED AND MODIFIED PATCH POCKETS.—Diagonally stitched corners reinforced with tape had significantly greater elongation at point of rupture than did pockets with nonreinforced corners.

The number of stitchings on the lapped seams into which sides of pockets had been inserted had no significant effect on elongation at point of break (table 27).

TABLE 26.—*Difference between means of elongation at point of break at corners of muslin patch pockets, as indicated by* t *values*

Type of stitching at pocket corner	Retraced	Triangular	Extended	Tied ends	Rectangular	Curved	Diagonal
Retraced	--------	0.404	0.772	*2.214	*2.269	**3.820	**8.878
Triangular	--------	--------	1.399	**3.083	**3.372	**6.018	**13.000
Extended	--------	--------	--------	1.499	1.457	**2.900	**8.064
Tied ends	--------	--------	--------	--------	.237	.805	**5.547
Rectangular	--------	--------	--------	--------	--------	1.287	**6.919
Curved	--------	--------	--------	--------	--------	--------	**7.216

*Significant at 5-percent level. **Significant at 1-percent level.

TABLE 27.—*Significance of differences between means of elongation at point of break at corners of patch pockets stitched diagonally, with and without reinforcements, and at corners of modified patch pockets, as indicated by* t *values*

Type of stitching at pocket corner	Diagonal stitching		Modified patch pocket (sides set in lapped seams)	
	Not reinforced	Reinforced	Double stitching	Single stitching
Diagonal:				
Not reinforced		**3.498	0.231	0.937
Reinforced			*2.301	1.435
Sides in lapped seams:				
Double stitching				.549

*Significant at 5-percent level. **Significant at 1-percent level.

RELATION OF VARIANTS TO TYPE OF DAMAGE AT RUPTURE OF POCKET CORNERS

Damage to the stitching, background fabric, and pocket fell into the following categories:

- Stitching—no break; thread pulled out; thread broke; thread pulled out and broke; thread broke and stitching ripped.
- Background fabric—no break or tear; slight tear; marked tear either vertically or at right angles to the stitching.
- Pocket—no tear; pocket slipped from jaw; tore at stitching; tore between the corner and jaw; tore at jaw.

PATTERN OF STITCHING.—In most of the pockets made with extended stitching, the threads broke or pulled out, particularly in those made from the high-count print. Background damage was relatively slight. When the pockets failed, a characteristic type of damage was a tear at the stitching at the top of the pocket. This type of damage was frequent in pockets made from the medium- and low-count prints with the higher number of stitches per inch.

When the retraced pattern of stitching was used for pockets on the medium- and low-count materials, the background fabrics tore along the line of stitching but the thread did not break, regardless of the size of stitch. In pockets of the high-count print, the thread often broke and damage to the background tended to become more severe as the number of stitches per inch increased. This tendency was more pronounced with a change from 11 to 14 than from 8 to 11 stitches per inch.

With rectangularly stitched corners on pockets made from medium- and low-count prints with 8 stitches per inch, and from the high-count print with 8 and 11 stitches per inch, the threads broke but the backgrounds usually remained intact. Occasionally both threads and backgrounds broke when the pockets were made from the best print. For pockets on the high-count print with 14 stitches per inch, threads continued to break and the background tended to have frequent slight or marked damage. As the number of stitches per inch was increased for the pockets on the medium- and low-count fabrics, there was a trend toward a decrease in thread breaks but an increase in severity of damage to the background materials.

For the muslin pockets with the seven patterns of stitching, there seemed to be a relation between strength at the corners and the kind of damage resulting from the rupture at the corners. In the majority of tests, background tears occurred with retraced and triangular stitching patterns, and thread breaks with extended stitching and tied thread ends—the four patterns that had the lower strengths. Thread breaks and background tears with varying degrees of damage occurred with rectangular, curved, and diagonal patterns of stitching, all of which gave higher strengths at pocket corners.

Marked tears in the background fabrics at right angles to the pocket sides frequently occurred without thread breaks at triangularly stitched corners. In a small percentage of these pockets, only the thread broke with little or no tearing of the backround material. In a few of the pockets with rectangular and diagonal stitching, tears also occurred at right angles to the pocket sides.

FABRIC, SIZE OF STITCH, AND THREAD.—Damage to the background fabric generally tended to be less severe when the high-count prints were used, but thread breaks occurred more often with the low-count fabric.

As the number of stitches per inch increased, damage to the fabric tended to increase, and damage to the thread to decrease. Differences in type of damage associated with the number of stitches per inch tended to be more marked between 11 and 14 than between 8 and 11 stitches per inch.

No clear-cut relationship between kind of thread and kind of damage was discernible as a result of the rupture at the pocket corners.

TAPE REINFORCEMENT AT CORNERS.—Thread breaks occurred most often with diagonally stitched pockets, either with or without reinforcement, and frequently these breaks were accompanied by slight background tears. When diagonally stitched corners were reinforced, background tears without thread breaks sometimes occurred.

MODIFIED POCKET CONSTRUCTION.—When the sides of patch pockets were inserted in lapped seams, the corners had a tendency to slip, probably because of the relatively low count of some of the fabrics. Sometimes this slippage was combined with a tear in the corner of the pocket, and sometimes with thread break.

ABRASION RESISTANCE OF BUTTONHOLES [6]

Resistance to abrasion is one of the characteristics that determines the serviceability of buttonholes. In turn, the kind of stitch, the number of stitches per inch, the thread, and the fabric on which

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[6] Information on abrasion resistance of buttonholes was published in large part in the Journal of Home Economics 41: 143-147 (March 1949).

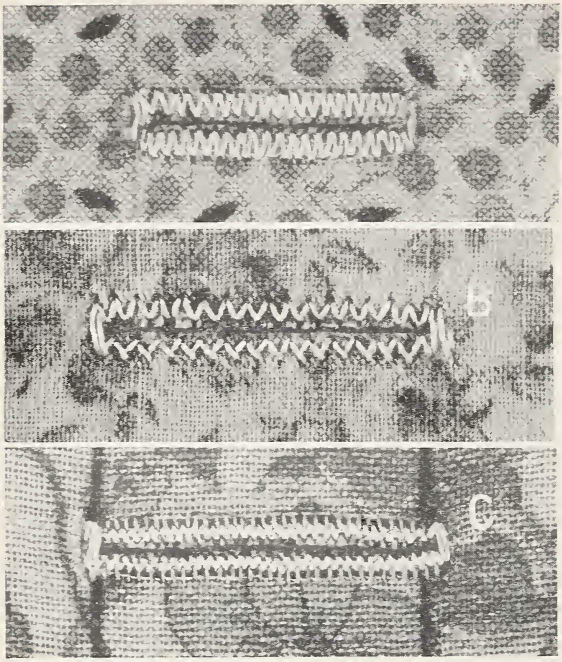

FIGURE 27.—Buttonholes: *A*, Whipstitch, attachment-made; *B*, whipstitch, machine-made; *C*, so-called purl stitch, machine-made.

the buttonholes are made influence their resistance to abrasion. To determine the effect of these factors, three types of commonly used buttonholes having various numbers of stitches per inch were made with different kinds of thread in cotton prints of different quality. The buttonholes were then abraded on a machine especially designed for the purpose.

The buttonholes studied included those made with whipstitches and those made with a stitch that is commercially referred to as a purl stitch. In this report the latter, which is not a true purl stitch, will be referred to as a so-called purl stitch. The buttonholes (fig. 27) were made as follows:

Whipstitch buttonholes—by attachment on a family-type lock-stitch sewing machine
Whipstitch buttonholes—by lock-stitch buttonhole machine [7]
So-called purl-stitch buttonholes—by lock-stitch buttonhole machine.

The whipstitch buttonholes made with an attachment are designated in this report as whip (a), and those with the buttonhole machine as whip (m).

The main difference between whip and so-called purl stitches lies in the position of the interlocking of the threads. For whipstitches, the tensions are adjusted so that the threads interlock in the fabric along the inside and outside edges of the stitches. For the so-called purl stitch, which is really a modification of the whipstitch, the tension on the upper thread is tightened, thus moving the interlocking of the threads to the top of the fabric, slightly back of the cut edge of the buttonhole.

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[7] The stitch made by the buttonhole attachment is not a true whip or zigzag stitch because it is formed by a moving of the fabric from side to side, instead of by the zigzagging movement of the needle bar. However, because both stitches look alike, they are both referred to as whipstitch in this report.

EXPERIMENTAL PROCEDURE

PREPARATION OF TEST SPECIMENS

Test specimens were made from the five cotton prints K, L, M, N, and O, the physical properties of which are given in table 1. Each specimen was double thickness and measured 9½ inches long and 6 inches wide, finished size. Ten buttonholes, as nearly identical as possible, were made fillingwise in each specimen. The number of stitches to the inch ranged from 8 to 48 along the cut edge of the buttonhole.

One brand each of four sewing threads commonly employed for making buttonholes at home or commercially was used. These were: 2-cord mercerized; 3-cord mercerized, A; and 6-cord unmercerized, 50 and 60. The physical properties of the threads are reported in table 6.

ABRADING THE BUTTONHOLES

In the absence of a suitable machine for determining the abrasion resistance of buttonholes, a special abrading machine was devised, utilizing the motor and framework of a shaking machine commonly used in chemical work (fig. 28). Supports for the removable specimen holder were fastened to the stationary framework of the shaking machine. The abradants and a counter were attached to the moving framework.

Ten steel rattail files, $\frac{3}{16}$ inch in diameter, were mounted vertically and used to abrade the edges of the buttonholes. The upper and under sides of the buttonholes were abraded by annealed tooled steel rings ½ inch in diameter, each having one lightly knurled surface. Abrasion for each abrading area was accelerated by brass ring weights which totaled 32.3 grams.

In preparation for abrasion of buttonholes, the under set of abrading rings was slipped on the files, and the holder with a previously conditioned test specimen [8] was fastened in place, one file extending through each buttonhole. The upper abrading rings and additional weights then were placed over the files.

Progress of abrasion was determined by stopping the machine, lifting the collars (weights) and the upper abrading ring, and examining the condition of the thread in the buttonhole stitches. The intervals between inspections varied, the buttonholes being examined frequently as they approached the point of failure. A buttonhole was considered to have failed when a thread broke or when a stitch was separated from the fabric. When a buttonhole failed, the number of abrasion cycles was recorded and the upper abrading ring and weights were removed from the file. A minimum of three specimens or 30 buttonholes was used for the average values reported in tables 28 and 29.

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[8] All test specimens were allowed to come to equilibrium with an atmosphere having a relative humidity of 65 percent and a temperature of 70° F., before any resistance-to-abrasion determination was made.

The condition of the abrading surfaces of the steel rings was examined periodically, usually after nine specimens had been tested. Standard samples for testing the abrading surfaces were made on print M (table 1), with 3-cord mercerized A thread, 17 stitches per inch. The knurled surfaces of the steel rings changed little during usage, and none was replaced until after 104 specimens had been abraded.

The resistance to abrasion of the threads used in making the buttonholes was determined in accordance with a procedure followed by Fletcher (*8*), which was essentially the same as that outlined by Hamburger (*9*). The durability and energy coefficients of the threads were also determined. The durability coefficients were calculated from curves of abrasion cycles plotted against percent reduction in breaking strength. The energy coefficients, which are a measure of the energy absorption capacities of the threads, were calculated from load-elongation curves. Hamburger describes the procedures for both determinations (*9*).

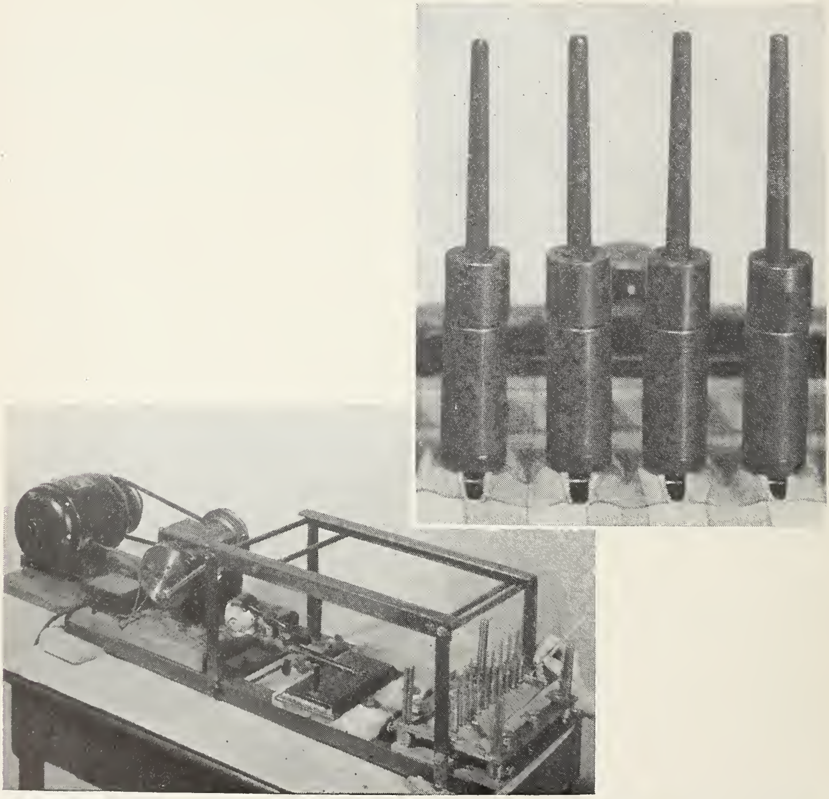

FIGURE 28.—Machine used in abrading buttonholes, and detail of abrading area.

TABLE 28.—*Abrasion resistance of whip (a) buttonholes worked fillingwise on high- and medium-count fabrics K, L, and M, with 3-cord mercerized A thread and various numbers of stitches per inch, and of so-called purl buttonholes worked simlilarly on medium-count fabric N*

Stitches per inch	Whip (a) buttonholes						So-called purl buttonholes	
	High-count print K		Medium-count print L		Medium-count print M		Medium-count print N	
	Cycles of abrasion	Variation	Cycles of abrasion	Variation	Cycles of abrasion	Variation	Cycles of abrasion	Variation
Number	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
8							1,524.8	50.6
16							2,556.8	64.1
17	1,390.3	51.0	1,542.1	42.1	1,023.3	50.5		
23	2,145.6	39.2	2,414.1	43.6	1,834.6	49.7		
27	2,689.5	43.5	3,021.8	33.9	2,234.4	51.7		
28							3,785.6	41.2
31	3,221.0	40.5	3,522.2	43.5	2,904.1	27.6		
37	4,132.7	47.7	4,488.6	46.0	3,616.7	39.8		
38							5,137.4	40.3
41	4,219.3	51.5	4,757.5	37.8	3,526.8	42.5		
48	3,994.2	44.5	4,917.8	31.2	3,411.6	31.0		

TABLE 29.—*Abrasion resistance of attachment-made buttonholes worked fillingwise on high- and medium-count fabrics K, L, and M, with mercerized and unmercerized thread and various numbers of stitches per inch*

Thread	Stitches per inch	Fabrics					
		High-count print K		Medium-count print L		Medium-count print M	
		Cycles of abrasion	Variation	Cycles of abrasion	Variation	Cycles of abrasion	Variation
	Number	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Mercerized: 3-cord A	17	1,390.3	51.0	1,542.1	42.1	1,023.3	50.5
	23	2,145.6	39.2	2,414.1	43.6	1,834.6	49.7
	31	3,221.0	40.5	3,522.2	43.5	2,904.1	27.6
Unmercerized: 6-cord 50	17	3,612.4	42.9	3,903.0	39.9	3,956.2	29.3
	24	4,323.5	42.2	4,748.0	36.2	4,319.2	39.6
	33	5,746.9	40.9	6,368.8	43.6	4,693.0	45.7
6-cord 60	17	2,083.6	30.9	3,203.5	47.2	4,153.7	49.2
	24	3,617.7	19.5	4,668.6	29.5	4,666.8	38.4
	33	5,422.1	50.6	6,753.8	36.5	5,570.3	36.6

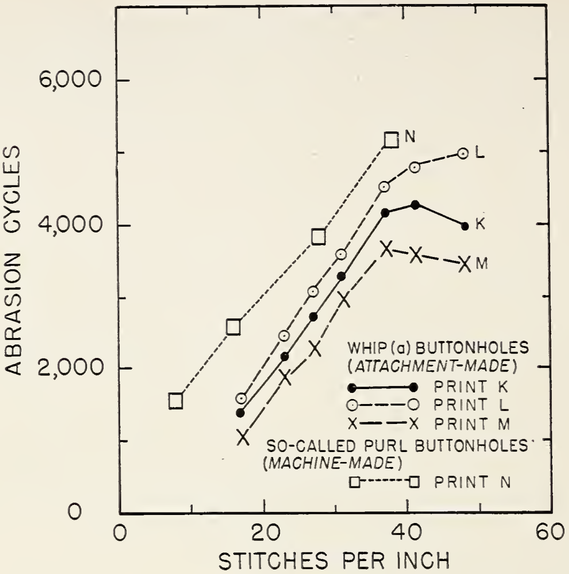

FIGURE 29.—Relationship of abrasion cycles and number of stitches per inch for whip and so-called purl buttonholes worked fillingwise with 3-cord mercerized A thread on fabrics with different counts.

RESULTS

The influence of the number of stitches, thread, fabric, and kind of stitch upon abrasion resistance of buttonholes is shown in figures 29 and 30.

NUMBER OF STITCHES.—The effect of increasing the number of stitches in buttonholes on their abrasion resistance (fig. 29) applies to buttonholes worked fillingwise with 3-cord mercerized A thread on cotton prints K, L, M, and N.

The number of abrasion cycles for whip (a) and so-called purl buttonholes increased in a linear relationship when additional stitches up to approximately 37 per inch were used. With a further increase in the number of stitches to 48 per inch, the abrasion resistance of whip (a) buttonholes on print L increased to some extent, whereas abrasion resistance of buttonholes on prints K and M decreased somewhat.

The mean percent variation in abrasion cycles for the 30 buttonholes made with different numbers of stitches on each of the prints K, L, and M was 42; the range in percent variation was from 28 to 52. Mean percent variations in abrasion cycles for the other groups of buttonholes were similar except for the whip (m) buttonholes worked on low-count print O, with 8 stitches per inch. The abrasion resistance of this group was low, and the variation (83 percent) was much higher than in the other groups, indicating that this fabric was unsatisfactory for buttonholes with so small a number of stitches.

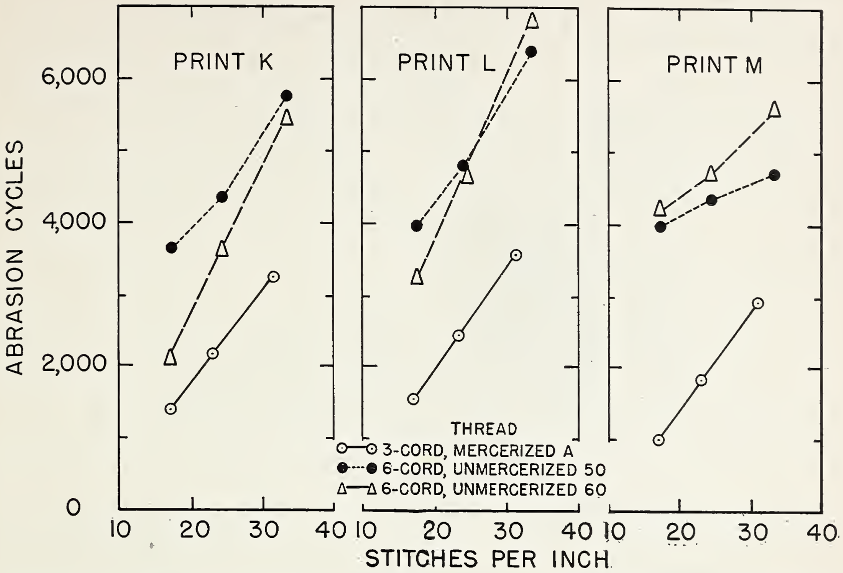

FIGURE 30.—Effect of kind of thread and number of stitches per inch on abrasion resistance of whip buttonholes worked fillingwise with a buttonhole attachment on fabrics with different counts.

THREAD.—Abrasion resistance of whip (a) buttonholes made with 6-cord unmercerized 50 and 60 threads, in general, far exceeded abrasion resistance of buttonholes made with 3-cord mercerized A thread (fig. 30). The abrasion resistance of similar buttonholes worked with 6-cord unmercerized 50 and 60 threads differed to only a small degree. The only significant difference was for those on high-count print K with approximately 17 stitches per inch.

In a limited phase of the study, no important differences in abrasion resistance were found between buttonholes made with 3-cord and 2-cord mercerized threads. When so-called purl buttonholes were worked entirely with 3-cord mercerized thread, their abrasion resistance was not significantly different from that of similar buttonholes made with 3-cord upper thread and 2-cord lower thread. Likewise, whip (m) buttonholes were not significantly different in abrasion resistance when worked entirely with 3-cord mercerized than when worked entirely with 2-cord mercerized thread. In these tests, the buttonholes were worked on print N with approximately 16 stitches per inch.

The superiority of 6-cord unmercerized over 3-cord and 2-cord mercerized threads was substantiated when the threads alone were abraded (table 30). The 6-cord unmercerized 50 thread was the most resistant to rubbing. This thread lost 100 percent of its original strength at 9,254 cycles; the 6-cord unmercerized 60 thread at 7,000 cycles; the 3-cord mercerized A at 6,250 cycles; and the 2-cord mercerized thread at 4,625 cycles—half the number

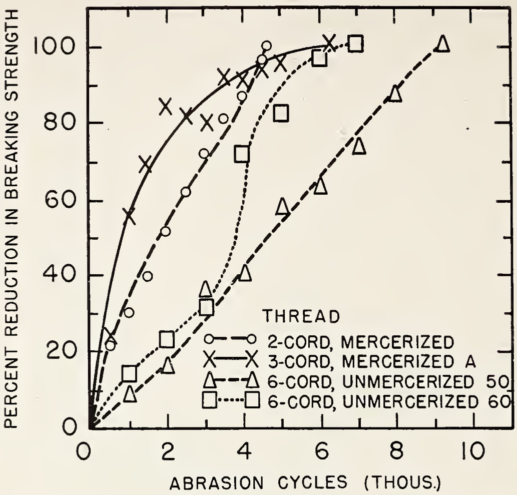

FIGURE 31.—Comparison of abrasion-rate curves of sewing threads.

of cycles required to abrade the 6-cord unmercerizd 50 thread to the point of rupture (fig. 31).

The durability coefficients calculated from the abrasion curves (fig. 31) and the energy coefficients calculated from the load elongation curves (fig. 32) are given in table 31. The durability coefficient for the 6-cord unmercerized 50 thread exceeded that for number 60, and both were larger than those for the 2-cord and

TABLE 30.—*Loss in breaking strength caused by abrading four sewing threads used in making buttonholes*

Cycles of abrasion	Loss in strength of mercerized threads		Loss in strength of unmercerized threads	
	2-cord	3-cord A	6-cord 50	6-cord 60
Number	*Percent*	*Percent*	*Percent*	*Percent*
500	22.1	23.9		
1,000	30.3	56.0	8.3	14.1
1,500	39.3	68.9		
2,000	51.0	83.7	16.7	23.2
2,500	61.4	81.3		
3,000	71.7	79.4	33.8	32.2
3,500	80.7	91.9		
4,000	86.2	90.4	40.3	71.2
4,500	95.9	93.3		
4,625	100			
5,000		95.2	57.9	81.9
6,000			62.0	96.6
6,250		100		
7,000			72.2	100
8,000			87.0	
9,254			100	

3-cord mercerized threads. The energy coefficients for the unmercerized threads were identical and larger than those for either of the mercerized threads.

Fabric.—Whip (a) buttonholes worked on the medium-count fabric L were consistently more resistant to abrasion than those on high-count material K and medium-count print M. Those worked on high-count print K were more resistant to abrasion than those on the medium-count print M.

The significance of the differences in resistance to abrasion was computed for buttonholes with 17, 37, and 48 stitches per inch. With 17 stitches per inch, differences significant at the 5-percent level were found between mean abrasion cycles for buttonholes worked on high-count print K and on medium-count print M; and at the 1-percent level for buttonholes on medium-count prints L and M. With 48 stitches per inch, differences significant at the 5-percent level were found between mean abrasion cycles for buttonholes worked on fabrics K and L; and at the 1-percent level

Table 31.—*Durability and energy coefficients of sewing threads calculated from abrasion and load-elongation curves*

Thread	Data from abrasion curves			
	Area	Cycles (abscissa)	Loss (mean ordinate)	Durability coefficient
		Number	*Percent*	
Mercerized:				
2-cord	[1] 260,000	4,625	56.2	[2] 82.3
3-cord A	[1] 487,200	6,250	78.0	[2] 80.2
Unmercerized:				
6-cord 50	[1] 458,400	9,254	49.5	[2] 186.8
6-cord 60	[1] 368,800	7,000	52.7	[2] 132.8
	Data from elongation curves			
	Area	Elongation (abscissa)	Ultimate strength (mean ordinate)	Energy coefficient
		Percent	*Percent*	
Mercerized:				
2-cord	[3] 71.16	1.37	51.9	[4] 0.026
3-cord A	[3] 86.28	1.59	54.4	[4] .029
Unmercerized:				
6-cord 50	[3] 104.96	1.92	54.6	[4] .035
6-cord 60	[3] 100.60	1.87	53.8	[4] .035

[1] Percent loss × cycles.

[2] Cycles/percent loss.

[3] Percent strength × percent elongation.

[4] Percent elongation/percent ultimate strength.

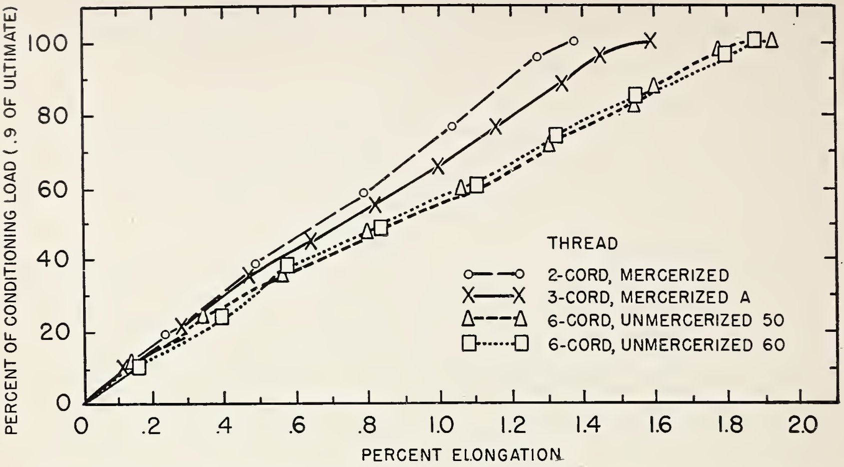

FIGURE 32.—Load-elongation curves of mechanically conditioned sewing threads.

for buttonholes on the L and M materials. With 37 stitches per inch, mean abrasion cycles were not significantly different for buttonholes on any of the three prints.

KIND OF STITCH.—The so-called purl buttonholes and whip (m) buttonholes worked on the same machine with 3-cord mercerized thread A on print N, with approximately 16 stitches per inch, differed in abrasion resistance. The so-called purl buttonholes withstood an average of 2,557 cycles of abrasion; whip (m) buttonholes failed with an average of only 1,522 cycles, a difference of 1,035 cycles, which is significant.

The so-called purl buttonholes made on medium-count print N were consistently more resistant to abrasion than the whip (a) buttonholes on high-count print K and medium-count prints L and M (fig. 29). Differences were significant at the 1-percent level between mean abrasion cycles for the so-called purl buttonholes on print N and whip (a) buttonholes on prints K, L, and M, with 17 stitches per inch, on prints K and M, with 27 stitches per inch; and on print M, with 37 stitches per inch. The difference between mean abrasion cycles for the so-called purl and the whip (a) buttonholes on print L, with 27 stitches per inch, was significant at the 5-percent level.

SUMMARY

To obtain basic information on construction details that affect the serviceability of cotton housework dresses, a study was made of the strength of seams, patch pockets, and buttonholes constructed in different ways on high-, medium-, and low-count prints. Variables tested, in addition to the effect of fabric quality and method of construction, were kind and size of thread and number of stitches per inch.

STRENGTH OF SEAMS

The study included five kinds of seams—plain, lapped, French, standing fell, and stitched fell—made in the following directions on the fabric: Warpwise, fillingwise, and at angles corresponding to those found in a side skirt seam at and below the curved hip area, at the lower back armscye, and in the shoulder seam of a princess-type dress.

Breaking strength at right angles to the seam and elongation at break were determined and observations were made of the type of damage to fabric and thread.

The effect of four variants—kind of seam, direction of seam, kind of thread, and number of stitches per inch—on the strength of seams on medium-count print was studied first. In the second phase of the research on seams, the effect of fabric quality was investigated.

Results showed a range of breaking strengths, measured across the seams, of from 11.6 to 41.0 pounds for the different kinds of seams.

With the medium-count prints, the variables ranked in descending order of influence as follows: Direction of seam in relation to warp and filling yarns, kind of seam, size of stitch, and kind of thread. All were highly significant.

In general, seams that ran fillingwise of the fabric or with the warp and filling yarns as they occurred in the lower back armscye were stronger than those that ran warpwise or at a fairly small angle to the warp, namely, in the side skirt seam. Shoulder seams that ran at an angle to the fillingwise yarns varied considerably in strength.

Stitched fell seams, on the average, were the strongest, although the superiority varied somewhat with the location of the seam. French and plain seams differed little from each other in strength and both were significantly stronger than the standing fell seams in many cases. Lapped and plain seams also were similar in strength. Standing fell seams tended to be the weakest.

The effects of size of stitch (number of stitches per inch) and kind of thread upon breaking strength of seams were of less importance than the direction and kind of seam. The influence of each size of stitch and kind of thread was more pronounced for fillingwise, shoulder, and armscye seams than for warpwise, skirt, and hip seams. In general, seams stitched with 11 and 14 stitches per inch were stronger than those with 8 stitches per inch. Seams stitched with 6-cord 50 unmercerized thread were slightly superior in strength to those stitched with 3-cord 50 and 2-cord 00 mercerized threads.

The effect of fabric quality on the breaking strength of seams was highly significant. When the low- and medium-count prints were used, plain seams made fillingwise were stronger than those made warpwise. However, when made on the high-count print, the fillingwise and warpwise plain seams were almost equal in strength. The greatest differences in strengths of seams due to the fabric count were noted for standing fell seams; the least, for stitched fell.

Although all the variables were highly significant in the elongation of seams at point of break with medium-quality prints, the direction of the seams was the most important factor. The effect of size of stitch, kind of seam, and thread upon elongation was minor compared with that of the direction of seams. Although seams made from the high-count print usually had the greatest elongation at break, seldom were important differences in elongation associated with the kind of fabric.

The types of damage caused by the break of the specimens included a rupture of the fabric at or away from the seam, slippage of fabric yarns, and a break in the thread or the stitching. With the stitched fell seam (in most instances the strongest), the fabric tended to break, probably because seam strengths were high in relation to fabric strength. With the standing fell seam (on the whole the weakest), the fabric yarns in the narrow edge of the seam tended to slip completely from the seam. With the plain, lapped, and French seams, thread breaks occurred most often in the fillingwise and shoulder positions, and fabric breaks occurred most often in the warpwise, hip, skirt, and armscye positions.

Fabric breaks tended to increase with an increased number of stitches per inch. The seams made with the strongest thread (6-cord mercerized, number 50) had comparatively fewer thread breaks than those stitched with the 3-cord 50 and 2-cord 00 mercerized threads. Fabric damage tended, in general, to be more frequent and more severe with low-count than with high-count fabrics.

STRENGTH AT PATCH POCKET CORNERS

In the first phase of the study of patch pockets, specimens were made from high-, medium-, and low-count prints with three commonly used patterns of corner stitching—retraced, rectangular, and extended.

Results of breaking-strength tests with these stitchings led to the study of four others—stitching with tied thread ends, and triangular, diagonal, and curved stitching. Pockets for this part of the study were made from bleached muslin, the physical properties of which were similar in some respects to those of the high- and medium-count prints.

Also investigated were the effects of tape reinforcement of diagonally stitched corners on pockets of medium-count print and the effect of modifying typical patch pocket construction by inserting the pocket sides in lapped seams with single and with double stitching.

Pattern of stitching, count of fabric, size of stitch, and type of thread were found to be highly significant sources of variation in breaking strength at pocket corners. Their influence ranked in descending order as listed.

Rectangular stitching was the strongest of the three commonly used patterns. Of the seven stitching patterns tested, the diagonal was by far the strongest—four times as strong as retraced, and almost twice as strong as rectangular stitching.

In general, the high-count print supported stronger pocket corners than did fabrics with medium or low counts. The superiority of pockets made from the high-count fabric was most evident with retraced corners. With rectangular stitching, the superiority of the high-count print was more pronounced with finer stitching (14 stitches per inch) than with coarser stitching (8 and 11 stitches per inch). In general, pockets made with 11 and 14 stitches per inch were stronger than those with 8 per inch.

In comparatively few tests were significant strength differences related to the use of different kinds of thread. Of these, the largest group included those in which the unmercerized threads, 6-cord 50 and 3-cord 50, showed superiority over the mercerized threads, 3-cord 50 and 2-cord 00.

Diagonal stitching of corners with tape reinforcement proved to be the strongest of the methods tried for attaching the pockets. Next were diagonally stitched corners without reinforcement, then modified patch pocket construction.

Size of stitch had the greatest influence on elongation at point of break at pocket corners, even though the effect of each of the other variables was also highly significant. In general, stitching with 8 and 11 stitches per inch stretched more than that with 14 per inch. The quality of fabric ranked second in influence but had considerably less effect upon elongation than did the size of stitch. The stitching at pocket corners made from the medium- and high-count prints tended to have greater elongation than on those made from the low-count prints.

The kind of thread and the pattern of stitching had relatively less effect on elongation at pocket corners than did either size of stitch or quality of fabric. The unmercerized threads showed some superiority over the mercerized. Of the seven patterns of stitching, the diagonal had the greatest elongation.

Various kinds of damage resulted from the rupture of the specimens, including damage to the thread, to the background fabric, and to the pocket itself. When the seven patterns of stitching were used, the effect on the thread and fabric varied with the breaking strength. In general, the muslin pocket corners with low strength had background tears or thread breaks, and those with high strengths had thread breaks combined with slight or marked background tears.

Diagonally stitched pocket corners reinforced with tape sometimes had background tears without thread breaks. Corners of the modified patch pockets tended to slip; sometimes the corners of the pockets tore and sometimes the thread broke.

ABRASION RESISTANCE OF BUTTONHOLES

In the study of abrasion resistance of buttonholes, the effect of the following factors was investigated: Kind of stitch; number of stitches per inch; quality of fabric; and kind of thread.

The buttonholes used were of three types: Whipstitch, made by an attachment on a family-type, lock-stitch sewing machine; whipstitch and so-called purl stitch, both made by lock-stitch buttonhole machine. The specimens were abraded on a machine devised especially for the purpose.

The main factors affecting the abrasion resistance of the buttonholes were the number of stitches per inch and the abrasion resistance of the thread used. The fabric and the kind of stitch used were contributing factors.

Abrasion resistance of the whip buttonholes made with an attachment and of the so-called purl buttonholes made by machine was improved by increasing the number of stitches up to a certain point. With more than approximately 37 stitches per inch, the resistance to abrasion of attachment-made whip buttonholes increased little and in some cases even decreased.

The unmercerized threads were more resistant to abrasion than were the mercerized threads. Likewise, buttonholes made with the unmercerized threads were more resistant to abrasion than were those worked with the mercerized threads.

The so-called purl buttonholes were more resistant to abrasion than the whip buttonholes.

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